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REPORT

ON THE

GEOLOGY,

MINERALOGY, BOTANY, AND ZOOLOGY

OF

Massachusetts.

MADE AND PUBLISHED BY ORDER OF THE GOVERNMENT OF THAT STATE:

IN FOUR PARTS:

PART I. ECONOMICAL GEOLOGY.
PART II. TOPOGRAPHICAL GEOLOGY.
PART III. SCIENTIFIC GEOLOGY.
PART IV. CATALOGUES OF ANIMALS AND PLANTS.

WITH A DESCRIPTIVE LIST OF THE
SPECIMENS OF ROCKS AND MINERALS COLLECTED FOR THE GOVERNMENT.

ILLUSTRATED BY NUMEROUS WOOD CUTS AND AN ATLAS OF PLATES.

SECOND EDITION, CORRECTED AND ENLARGED.

BY EDWARD HITCHCOCK, A. M.
Professor of Chemistry and Natural History in Amherst College: Member of the American
Academy of Arts and Sciences: Of the Academy of Natural Sciences, Philadelphia:
Of the American Geological Society, &c.

AMHERST:
PUBLISHED BY J. S. AND C. ADAMS.
1835.

Entered according to Act of Congress, in the year 1834, by EDWARD D. BANGS, Secretary of the Commonwealth of Massachusetts, in the name and behalf of said Commonwealth; in the Clerk's Office of the District Court of the District of Massachusetts.

To His Excellency, John Davis, Esq.
Governor of Massachusetts.

I have the honor to present you with the second edition of my Report on the Geology, Mineralogy, Botany and Zoology of the State, published in conformity to a Resolve of the Legislature of the 17th Feb. 1834. That Resolve did not allow either time or means for making further explorations of our geology and mineralogy: nevertheless, I have been able to make not a few corrections of, and additions to the first edition. The most important and extensive changes will be found in the Catalogues of our Animals and Plants, embraced in the Fourth Part. By the great kindness and effort of the gentlemen who furnished these Catalogues, nearly all of them have been re-written, and several of them nearly doubled in extent. They have all likewise been reduced to the most approved and correct classification, and are now printed in a uniform manner. In effecting these objects, I have been greatly aided by the Boston Society of Natural History. The gentlemen of that Society who have assisted me most, are Dr. Charles T. Jackson, in the department of geology and mineralogy; Dr. Augustus A. Gould, in the crustaceous and radiated animals; Amos Binney, Esq., in conchology; C. C. Emerson Esq., in ornithology; and Mr. Moses A. Curtis, in Botany.

Some of the plates of the Atlas in the present edition have been lithographed anew; and the geological Map, as well as the sketch of autumnal Scenery, have been colored with more care than in the first edition.

Upon the whole, I cannot but hope that the efforts that have been made (and they have been by no means small,) to improve the Report, will meet the approbation of the Government; and that they will regard their liberality in publishing a second edition, as not entirely unrewarded.

Respectfully Submitted,

Edward Hitchcock.

Amherst College, Dec. 1st, 1834.

INTRODUCTORY OR HISTORICAL NOTE.

On the 3d of March 1830, the Legislature of Massachusetts passed a Resolve, authorizing and requesting the Governor with the advice of the Council, 'to appoint a Surveyor well skilled in astronomy and in the art of surveying upon trigonometrical principles—to make a general Survey of the Commonwealth, and from such astronomical observations and calculations as may be made, to project an accurate skeleton plan of the State, which shall exhibit the external lines thereof and the most prominent objects within those lines and their locations.'

In Governor Lincoln's Message to the Legislature May 29th, 1830, we find the following recommendation.

'I beg leave to suggest to your consideration the utility of connecting with the Geographical Surveys, an examination of the geological features of the State, with a view to the exhibition of them on the map. Much knowledge of the natural history of the country would thus be gained, and especially the presence of valuable ores, with the localities and extent of quarries, and of coal and lime formations, objects of enquiry so essential to internal improvements, and the advancement of domestic prosperity, would be discovered, and the possession and advantages of them given to the public. I am assured that much has already been gratuitously done, by some eminent professors in our colleges, towards the accomplishment of such a work, and that, at a little expense, it might be completed, and the fruits of their generous labors thus far, be secured to the State. This, however, will require the interposition of your authority in increasing the present appropriation, and permitting an application of it, so far as may be necessary, in the exercise of a sound discretion, to the end proposed.'

In conformity with these suggestions, the Legislature, on the 5th of June, 1830, '*Resolved*, That his Excellency the Governor, by and with the advice of the Council, be, and he is hereby authorized to appoint some suitable person, to make a geological examination of the

'*Resolved*, that the said five hundred copies, when published, shall be delivered to the Secretary of the Commonwealth, and be distributed in the following manner, viz.

Twelve copies to the Governor;

Ten copies to the Surveyor;

One copy to each of the Chaplains of the Senate and House of Representatives;

One copy to each incorporated Lyceum and Atheneum in this Commonwealth;

Two copies each to the Berkshire Medical Institution, and the Massachusetts Medical College;

One copy to each member of the Council, Senate, and House of Representatives, who was not a member of either of those branches of the government for the last year;

One copy to each of the permanent Clerks in the office of the Secretary of State, Treasurer, and Adjutant General;

Two copies to the Pilgrim Society at Plymouth; and the remaining copies to be disposed of in such manner as the Legislature may direct.'

A more particular account of the alterations and additions made in the present edition, (which is the second edition of the whole work, and the third edition of the first part,) published in conformity to the last of the preceding Resolves, will be found in the address to Governor Davis a few pages back.

Enquiries having been frequently made by gentlemen in different parts of the United States, as to the expense of this Geological Survey of the State, it may not be amiss to state, that the sum paid for making the Survey, preparing the Report, and collecting, labelling, and arranging 1550 specimens of rocks and minerals for the Government, and about 900 specimens for each of the three Colleges in the State, has been only Two Thousand and Thirty Dollars. It was only by rigid economy, and laborious industry, however, that the expenses have been kept within such limits. The cost of printing the several editions of the Report, is not, of course, included in the above estimate.

The Government have permitted the Boston Society of Natural History to deposite the collection of specimens above spoken of, in their beautiful and spacious Cabinet; where provision has been made for its reception.

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REPORT.

PART I.

ECONOMICAL GEOLOGY.

To His Excellency Levi Lincoln, Esq.
Governor of Massachusetts.

Having in a good measure executed the commission received from your Excellency, bearing date June 25, 1830, and directing me to make a geological examination of the State; I beg leave to present you with the first part of my Report.

My commission contemplates an exhibition of the different rock formations in the State, upon the Map of the Commonwealth now in progress. But as it must necessarily be a period of considerable length before that work can be completed, I have constructed a small map from such materials as already exist, and delineated upon it the various kinds of rock that prevail in the State. These are shown by different colors and simple markings, easily understood by reference to the tablets on the lower part of the sheet.

To avoid confusion, I have placed on this Map only so much of topography and geography, as was absolutely necessary. All the mountains and smaller rivers, with the boundaries of the towns, have been omitted; the center of each town being indicated by a small circle. For the same reason, I have employed only six different colors to mark the rocks; although more than twenty kinds are represented. But these, with a few exceptions, may be grouped together, as they are in nature, in general divisions; the rocks in each division being so intimately related, that in an economical point of view, they may be regarded as varieties; although, in a scientific point of view, their differences are very important. All the rocks of a group have a common color on the Map; and the different sorts are delineated by means of dots, crosses, circles, &c. In short, it has been a great object with me, so to simplify the Map as to render it easily intelligible; while it exhibits all that is important to the practical man, as well as to the scientific enquirer. In the first part of my Report, I shall explain the different formations on the Map, only so far as shall be necessary in illustrating our geology with reference to the useful arts; reserving the most important scientific remarks to a subsequent period.

It will be seen that I have extended the Map a short distance into the adjoining states. This was done chiefly with a view to exhibit certain beds of ore, or other interesting minerals, which occur just beyond our limits. In a statistical point of view, these are nearly as important as those found within the State; and for this reason I shall notice such minerals in my Report.

In laying down the geology of the eastern part of Rhode Island, I have been much assisted by the communications of Col. Joseph G. Totten of Newport. In the geology of Berkshire, I have been greatly aided by the geological map of that county, published a few years since by Professor Dewey.

It has been my intention to give to each rock precisely that relative extent on the Map which it occupies on the earth's surface. To do this with perfect accuracy, over an extent of more than seven thousand square miles, would be almost an endless task: especially when we recollect, that over the greater part of the surface, the rocks are covered by loose soil; so that in some instances, no rock in place shows itself to the traveller, for an extent of thirty or forty miles. In such cases, indeed, this stratum of sand, clay, and gravel, has been exhibited under the name of diluvium. Still, under the most favorable circumstances for observation, the effort to give on a map the exact boundaries of each particular rock, must be regarded as only an approximation to the truth. Yet, for all practical purposes, such approximation answers nearly as well as entire accuracy. If I have not misunderstood my commission and instructions, I was to have principally in view, in my examinations, practical utility; not neglecting however, interesting geological facts, which have an important bearing upon science. Under such impressions I have gone over the State as rapidly as seemed to me consistent with the accomplishment of these main objects. In attempting to construct such a map as is appended, in the time that has been devoted to the survey, I am not without fears that I shall be thought to have aimed at too much; or that it will be supposed little dependence can be placed upon it. Had I not previously become acquainted with the geology of nearly one half the State, from my own observation, or the published accounts of Professors Dewey, Webster, and the Danas, I should not have been able to accomplish this object, with any confidence in the correctness of the results. And as it is, I am aware that the Map may need several minor alterations; though I feel quite confident of the correctness of its leading features. To obtain such corrections before the completion of the contemplated map of the State, is one strong inducement, thus early to present this Report, and the accompanying Map.* For, should the Report in any way be made public, I shall hope that gentlemen of intelligence, in different parts of the State, will do me the favor to communicate any errors or omissions which they may notice.

I propose to divide my Report into four parts. The *first part* will embrace the ECONOMICAL GEOLOGY of the State; or an account of our rocks, soils, and minerals, that may be applied to useful purposes, and thus become sources of pecuniary profit.

The *second part* will embrace our TOPOGRAPHICAL GEOLOGY; or an account of the most interesting features of our scenery.

The *third part* will consist of our SCIENTIFIC GEOLOGY; or an account of our rocks in their relation to science.

The *fourth part* will consist of catalogues 'of the native mineralogical, botanical, and zoological productions of the Commonwealth,' so far as they can be obtained, agreeably to a resolve of the Legislature, approved by your Excellency, February 2, 1831. Several gentlemen, distinguished for their attainments in natural history, have generously offered to furnish these lists in those branches with which they are most familiar.

To illustrate the first and third parts of the Report, I have in accordance with directions from your Excellency, collected specimens of every variety of rock I could find in the Commonwealth; and in all cases where a rock is quarried, or might be quarried in several places, I have endeavored to obtain specimens from each locality. I have collected likewise all the ores of importance found in the State, as well as the other simple minerals, which could be obtained without much difficulty or delay. I did not suppose that my instructions authorized me to be at much expense and trouble in procuring every rare mineral that has been described as occurring in the State; although this object may still be accomplished, if I have mistaken the intentions of the Government. The collection which I have made for the use of the Government contains 1550 specimens. I do not know to what use the Government intends to devote this collection. But supposing it would be placed in some public situation, in order to exhibit to the citizens the geology and mineralogy of the State, I have endeavored to obtain from all the important quarries and beds, whence stones are derived for the purpose of architecture or ornament, specimens which would fairly exhibit the qualities and value of each. About 130 of these specimens I have had polished, or smoothed and varnished, in order to bring to light their real qualities.

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* The Geological Map contained in the Atlas accompanied the first part of this Report in its first edition, but none of the other drawings.

I have also, in accordance with my instructions, endeavored to collect all the important varieties of rocks and minerals in the State, for the use of each of the colleges in the Commonwealth: though the number of specimens is not as great as in the collection for government; amounting to a little more than 900 specimens for each college.

In presenting a view of our economical geology, I shall first make a few remarks upon the different soils found in the State, as connected with the rocks over which they lie. And since it is an acknowledged fact, that all soils had their origin in the disintegration, or decomposition of rocks, it might seem easy, at first thought, to ascertain the nature of the soil, if we know the integrant and constituent parts of the rock underneath it. Thus, in a soil lying above granite, we might expect that siliceous sand would be the predominant ingredient; next, clay, with small quantities of potash, lime, magnesia and iron; because these are the constituents of granite. But several causes so modify soils, as to render all conclusions of this kind extremely uncertain. In the first place, the character of a soil depends more, in general, upon the nature and amount of the vegetable and animal matters it contains, than upon the nature of its other ingredients. And in the second place, the agency of running water, not merely of existing streams, but of mightier currents to which the surface has been exposed in early times, has been powerful in modifying the loose coverings of the rocks. This aqueous agency has often covered one rock with the spoils of another; and sometimes mixed together the worn off fragments of half a dozen, and accumulated them in immense quantities in particular districts. These circumstances have rendered the subject under consideration an extremely difficult one; and very few general principles have yet been settled concerning it. Indeed, so far as I know, little attention has been given to it in this, or other countries. Still, there is such a thing as peculiarity of soil, occasioned by the peculiarity of the rock from which it principally proceeded. I shall notice any peculiarities of this kind, that have struck me, in the soils of Massachusetts; but I shall not enjoy much advantage from comparison, not having found but few observations of a similar kind, made on the eastern continent. I shall begin with the stratum that lies above every other;—viz. *alluvium.*

Alluvium.

In this part of my Report, I shall not enter into a systematic and minute description of the various formations represented on the accompanying geological Map. Such description belongs more appropriately to the scientific part. I shall here describe the different strata only so far as is necessary to the particular purpose I have in view.

Alluvium is, for the most part, that fine loamy deposit, which is yearly forming from the sediment of running waters, chiefly by the inundations of rivers. It is made up, of course, of the finest and richest portions of every soil over which the waters have passed. Hence alluvial meadows have always been celebrated for their fertility. No extensive alluvial tracts occur in Massachusetts; although limited patches of this stratum exist not unfrequently along the banks of every stream, and with the adjoining elevated ground covered by wood and pasture, constitute not a few of the most productive farms in the State. Even where Deerfield river winds its way among the lofty and precipitous spurs of Hoosac mountain, which crowd so close upon the path as almost to throw it into the shade at noon-day, the traveller is sometimes agreeably surprised to see a luxuriant meadow open before him, rewarding the labors of some thrifty farmer. No alluvial tracts, however, have been thought of sufficient extent to deserve a place on the Map, except one or two salt marshes a little northeast of Boston, and several meadows along the Connecticut, Deerfield, and Housatonic rivers. Those of Longmeadow, Springfield, Northampton, Hadley, Hatfield, Deerfield, and Northfield, have long been celebrated for their unrivalled exuberance and beauty. Those in Great Barrington, Stockbridge, and Sheffield, are scarcely less inviting.

There is one variety of alluvial soil in this State, that deserves more attention from our agriculturalists. I refer to those numerous uncultivated swamps, which have for ages been the reservoirs of rich soil, that has been washed thither by rains and brooks. To reclaim them, does, indeed require not a little labor and expense. But where the effort has been successful, the great and continued exuberance of these spots, has astonished and amply repaid the experimenter. Even in those cases where they cannot be reclaimed, which I believe to be few, they ought at least to be converted into manure, and spread again over those higher regions around, from which, by slow aqueous agency, they have been washed away. Very many of the most barren regions in the State, might, by this means, be clothed with fertility and plenty.

Diluvium.

This occupies more of the surface in Massachusetts than any other formation. It is not generally distinguished from alluvium: but it is usually much coarser, being made up commonly of large pebbles, or rounded stones mixed with sand and fragments of every size, which are often piled up in rounded hills to a considerable height; and under such circumstances, as preclude the probability that it could have resulted from existing streams. Indeed, it is spread over the highest mountains, wherever it could find a lodgment, and appears to have resulted from powerful currents of water, which, in early times, swept over the globe.

In a scientific point of view, this is one of the most interesting formations in the State; and in the proper place, I shall exhibit several facts respecting its relations and mode of occurrence. But in an agricultural point of view, it is the least interesting of all our strata: for of all the soils, it is the most unfriendly to rich vegetation. And as it is spread in a good measure over every kind of rock, it often prevents the formation of a good soil, from the decomposition of the rock. It is in general easily recognised in the most sterile places, in the form of low rounded hills, composed almost entirely of pebbles, or cobble stones, and sometimes larger rounded masses of rock, called bowlders, mixed with coarse sand, and covered with a stinted vegetation. It was evidently deposited by currents rushing violently over the surface; since only the coarse materials, which were driven along, were left; while the finer particles were kept suspended by the agitation of the waters. Some varieties of this diluvium may indeed be converted into a soil of tolerable richness by manuring it abundantly, and clearing away the stones. And generally too, the rains that have fallen upon it for thousands of years, have conveyed its finer particles to the bottom of the vallies and cavities, with which this formation abounds, and these being mixed with much vegetable decayed matter, a soil of good quality is formed. So that within the limits of this formation much good land occurs. But these fertile spots ought perhaps rather to be denominated alluvium than diluvium.

Had diluvium been represented on the Map wherever it occurs, scarcely any other formation could have been exhibited. I have marked the region as diluvial, only where it occurs in such quantities, as almost entirely to conceal every other stratum. It is most abundant in the south east part of the State; the counties of Plymouth, Barnstable, Dukes, and Nantucket, being almost entirely overspread by it; so that in the three latter counties, I scarcely found any rocks that did not appear to have been broken up and moved from their original bed. Towards the extremity of Cape Cod, this stratum is composed almost entirely of sand; which often constitutes those hills called *downs* or *dunes*,* that travel inland by the action of winds and do great mischief, by overrunning fertile spots; and on the eastern continent, by burying even villages and cities. The most effectual remedy that nature has provided against these encroachments, seems to be Beach Grass;—(*Arudo arenariă*, Lin. *Psamma arenaria*, Beauv.) which is able, not only to fix its roots in the most barren ridge of sand, but also in time to fix the sand itself.

Diluvial tracts of considerable extent exist in the county of Norfolk, in the Connecticut valley, and along the western base of Hoosac Mountain. None of them however are noticed on the Map. Most of the islands in Boston Harbor are thus colored: and a part of Malden and Chelsea.

Tertiary Formations.

The only difference between these and diluvium, is, that in diluvium, the sand, pebbles, and clay, are confusedly mixed together; exhibiting only an imperfect stratification; but in the tertiary formations, these materials are arranged in regular, and generally in horizontal layers, one above another, and appear to have been deposited at earlier epochs, and in calmer waters. Hence, when the sandy stratum happens to lie uppermost, the soil will be too sandy; but if this be worn away, so that the clay lies at the surface, the soil will be too argillaceous; or if the gravel stratum be exposed, the soil cannot be distinguished from diluvium. Most of the varieties of soil thus produced, may be seen in the valley of the Connecticut; where exists the most extensive tertiary formation in the State; extending nearly to Middletown in Connecticut. Upon the whole, there is little to choose in an agricultural point of view, between those tertiary formations that occur in Massachusetts, and our diluvium, although in England, some of these formations, that embrace beds of loam and marl, are very productive. But it is doubtful whether more than one of our tertiary formations are identical with any in Europe. At any rate, ours contain no marl, and very little loam; and where the sand is uppermost, much of the soil corresponds to those unimproved and unimprovable tracts, that occur in the immediate vicinity of the English metropolis—composed of what is locally denominated bagshot sand. Where the clay predominates, however, cultivation and proper manure produce a valuable soil. Of this description are the small tertiary patches on the Map in the vicinity of Boston. There, in fact, the clay near the surface appears generally to have been disturbed, and to be a kind of loam; and it is doubtful whether they ought not rather to have been colored as diluvium, than as tertiary. It ought also to be remarked, that the sandy plains along Connecticut river, are very congenial to the growth of rye, and are very easy to cultivate.

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* Dunes are properly alluvial phenomena, though diluvial sand (as in the case mentioned in the text) is often employed in their production.

New Red Sandstone.

This is found in the valley of the Connecticut. Although composed of numerous varieties of rock, the prevailing color is red; and the reddest varieties are most liable to decomposition; viz. a red slate and a red sandstone. No rock in the State disintegrates so easily as this; nor has any other so impressed its peculiar characters upon the soil. In Longmeadow, Wilbraham, Southwick, West Springfield, Easthampton, and Greenfield, it is common to see tracts of considerable extent, where the diluvium and tertiary are chiefly swept away, exhibiting that reddish aspect, which in England is so characteristic of soils derived from this formation. The Devonshire butchers, it is said, are able to distinguish the sheep raised on this soil, by the color of their fleeces; and many local names in that country originated from the same circumstances; such as Rougemont Castle, in Exeter; Red Hill and Redford, in Somersetshire; Red Brook, in Gloucestershire; Red Mire, Rotherham, &c. in Yorkshire.

The new red sandstone is said to be associated with some of the most fertile land in England; especially that variety of the rock denominated red marl. It is distinguished for the excellence of its wheat, barley, beans, and cider. The sand resulting from the decomposition of the coarser varieties of the rock, produces most of the rye grown in England. In that country, however, this formation contains not a little limestone, either in beds, or impregnating the sandstone. But in Massachusetts, the lime is in small quantity; and hence, probably, it affords a soil inferior to that produced by the English rock. Still, with us its soil is of a superior quality. Its poorer varieties are excellent for rye. It is also peculiarly well adapted for fruit. The grass grown upon it is of a superior quality; and it affords excellent pasture. The establishment of the Shakers in Enfield, Ct., exhibits a favorable example of the productiveness of this soil, when under a good cultivation. The black, white and red oaks, with pignut hickory, chesnut, and soft maple, (*Acer rubrum,*) are the forest trees most naturally produced upon this soil.

Argillaceous Slate and Graywacke.

The argillaceous slate in the vicinity of Boston, is intimately connected with the graywacke, and may perhaps be considered as a variety of that rock. It is considerably different from the argillaceous slate of Worcester, Franklin, and Berkshire counties. Every variety, however, furnishes by decomposition, a dark colored soil, which, although somewhat apt to be cold, is capable of being made very fertile. The central parts of Quincy, exhibit a favorable example of the soil lying above this rock. The range in Worcester county, is almost every where overspread with diluvium, and in Franklin and Berkshire, this rock is so limited in extent, as not very strikingly to develope the peculiarities of its superincumbent soil. Professor Dewey, however says, that in Berkshire 'the argillaceous district is more fertile and productive than any other portion of the section, except the alluvial.'

Numerous varieties of rock, differing both in color and composition, are associated under the term Graywacke, from the fine dark colored shale or slate, containing the anthracite coal of Rhode Island, to the coarse conglomerate or plum-pudding stone, of Roxbury, Dorchester, Dighton, Somerset, and Swansey. Most of these varieties, however, appear to furnish a soil of good quality, and sometimes of superior fertility. The Island of Rhode Island exhibits the superiority of the soil of this formation, to that of several others that surround it. As we proceed northerly, the great quantities of diluvium spread over the surface, obliterate, or greatly modify the soil peculiar to the formation. But in Dorchester, Roxbury, Brooklyn, Brighton, and Newton, it is exhibited to great advantage; presenting the finest examples of exuberant farms and gardens in the Commonwealth; although we must not forget the very superior cultivation that has been bestowed upon that part of the State. Still, such luxuriance as we there witness—such fine fruit especially—could not be produced without a soil naturally excellent.

Iron Ore.

No ore except that of iron occurs in sufficient quantity in the State to deserve notice in an agricultural point of view. In the west part of Worcester county, the soil, for a width of several miles across the whole State, is so highly impregnated with the oxide of iron, as to receive from it a very deep tinge of what is called *iron rust*. This is particularly the case in the low grounds; where are frequently found beds of bog ore. I do not know very definitely the effect of this iron upon vegetation; but judging from the general excellence of the farms in the Brookfields, Sturbridge, Hardwick New Braintree, Barre, Hubbardston, &c., I should presume it to be good. Certainly it cannot be injurious; for no part of the county exceeds the towns just named in the appearance of its farming interest; and nearly all the county, as may be seen by the Map, is of one formation. It would be an interesting problem, which in that county can be solved, to determine the precise influence of a soil highly ferruginous upon vegetation.

Steatite, Serpentine, Scapolite Rock, Limestone.

The next rocks, in an ascending order upon the tablets attached to the Map, are steatite or soapstone, serpentine and scapolite rock. But they are of such limited extent as to deserve no notice in this connection. The next rock, namely, limestone, is found only in Berkshire county, in quantities sufficient to modify the soil over much extent of surface. But in that county it occupies most of the vallies; while the mountains are chiefly mica slate. And the fertility of these vallies is a striking evidence of the good influence of disintegrated and decomposing carbonate of lime upon the soil. Indeed, I believe that it is generally thought in Europe, that soils of this description are more productive than any other, except rich alluvions. And I apprehend that one of the greatest deficiencies in the soil of the principal part of Massachusetts, is the absence of lime. Probably if our farmers could procure this article at a moderate expense, its application as a manure would amply reward them for their trouble. Limestone that contains much magnesia, is, indeed, said to be injurious to vegetation, unless it be upon peaty soil, or soil containing much vegetable matter; and this limestone is common in Berkshire county. But it occurs there in beds, alternating with the pure carbonate of lime, and I apprehend rarely produces any bad effect.

Quartz Rock.

It will be seen by the Map that one variety of this rock is associated with mica slate, and another with gneiss; so intimately, indeed, that its agricultural character may be considered the same as that of these rocks. When it occurs in the state of pure quartz, it is so little acted upon by the common decomposing agents, such as air, heat, and moisture, as to exert little or no influence upon the superincumbent soil; except in the town of Cheshire, where it produces a pure white sand.

Chlorite Slate, Talcose Slate, Mica Slate.

The first of these rocks occupies too little space to deserve any notice in respect to the soil resulting from it. The second is in general a mere variety of mica slate, talc taking the place of mica, or being superadded to it. Where the talcose slate, however, is most pure, so as in fact to be little else but slaty talc, with more or less quartz, the soil which its decomposition produces, is decidedly inferior to that resulting from mica slate; and probably this is owing to the large quantity of magnesia which talc contains.

Mica slate produces a soil of medium quality. Some varieties of it underlie tracts of superior excellence. But the most extensive region of mica slate in Massachusetts, consists of the high and mountainous region west of Connecticut river: so that it is difficult to compare the soil lying over it, with that of formations at a lower level. The deep ravines, however, so common in the mica slate, furnish many very fertile, though limited patches of ground; while the mountain sides are very superior for grazing.

Hornblende Slate, Gneiss.

Gneiss, which differs from granite only in having a slaty structure, occupies more of the surface of the State than any other rock. It sometimes takes into its composition the black mineral called hornblende; even losing its common ingredients; and then it is denominated Hornblende Slate.

The soil resulting from the decomposition of gneiss is so well marked, as not to be easily mistaken by an experienced eye. Its predominant ingredient is a rather fine whitish sand; and sometimes beds of extremely pure sand result from it, as in Pelham and Shutesbury. Indeed, the appearance of the soil from gneiss, indicates uncommon poverty and sterility. But facts do not correspond to this anticipation; for in no part of the State do we find finer looking farms, or the appearance of more thrift and independence among their occupants, than in the region where gneiss prevails; I refer chiefly to Worcester county, most of which is based on this rock. The western part of the range, however, embracing the eastern part of Franklin, Hampshire and Hampden counties, is in general characterized by a rather barren soil. But this region is more elevated than the surface farther east. Where it is not so high, as in Monson and Brimfield, we find the same appearance of fertility as in the towns farther to the east. It is a question worthy of attention, however, how far the soil from our gneiss may owe its agricultural character to the iron that so generally accompanies this rock. Certainly the iron gives it an appearance of sterility which does not belong to it.

Greenstone.

This is one of the varieties of rock embraced under the general term *trap rock.* The variety most common in Europe is basalt, and the soil produced by its decomposition is said to be of a superior quality. The greenstone of Massachusetts, however, except some of its rarer varieties, is but little acted upon by ordinary decomposing and disintegrating agents; and is proverbially one of our hardest and most indestructible rocks. Hence the soil that covers it is generally quite scanty. It is, however, very peculiar; and we find upon our greenstone ridges, quite a number of plants, shrubs, and trees, that are not found, except rarely, upon the other formations. The eastern part of the county of Essex is in a great measure composed of greenstone; and its superior agricultural character, in general, produces a favorable opinion as to the influence of this rock upon the soil, though very much must be imputed to good management. This formation in the Connecticut valley furnishes but little arable land, and that of rather a sterile character.

Porphyry.

This rock offers but little interest in an agricultural point of view. It is of quite limited extent and is decidedly the hardest and most unyielding of all our rocks. It occupies the greater part of the surface, and the scanty soil that has formed a lodgment in its inequalities, is not of the first rate character.

Sienite and Granite.

Sienite is intermediate in its characters between greenstone and granite, although most commonly it is only a variety of granite. Both rocks are little liable to decomposition, and occupy a large porportion of the surface with their naked and rugged projections. Still, the soil found among them, particularly on the granite, is generally of a superior character, probably from the fact that most of it must have been derived from decomposed vegetable and animal matter. Hence it is usually of a dark color and fine texture, and not coarse and sandy like the soil above the granites of Europe, that more easily suffer decomposition.

Should the preceding cursory remarks be the means of exciting the attention of intelligent agriculturalists, to the connection between rocks and soils, an important object will be attained. I have said enough to show that almost all known varieties of soil exist in Massachusetts. But much improvement remains to be made in our agricultural concerns, before the excellencies of our soil are fully developed. It is but a moderate estimate to say, that the general adoption of an enlightened system of cultivation, would, in a few years, double the produce and the value of our improvable lands.

That is to say, such would be the speedy result, if all our farmers were to manage their lands as a few now do.

USEFUL ROCKS AND MINERALS IN THE STATE.

I shall next proceed to give an account of those rocks and mineral substances found in the State, which have been, or may be useful in the arts, and are consequently objects of pecuniary importance. Those that are employed for architectural or ornamental purposes, first claim attention; because the State is peculiarly rich in treasures of this kind. It will be easy to see, by a refererence to the Map, how extensive are the formations from which they are derived; although it must not be concluded that every part of a formation will furnish materials of equal value for economical purposes.

Granite and Sienite.

Much confusion has arisen in the application of these terms. They were originally applied to designate rocks very different, if not in composition, yet in their geological relations. But most of the rock that is generally described as sienite, is a variety of granite. This is certainly the case in Massachusetts. Wherever the granite admits hornblende into its composition, I have considered it as a sienite; and not unfrequently the hornblende constitutes the principal ingredient; taking the place, more or less of the quartz and mica, so as to form a compound of hornblende and feldspar. This compound forms some of the most beautiful varieties of sienite, though extremely hard to work for architectural purposes. But not a little granite that contains no hornblende goes by the name of sienite. Thus, much of the Quincy granite is wanting hornblende; but being almost destitute of mica, and having the close aspect of sienite, it is called indifferently by either name.

The variety in the composition, color, and hardness of these rocks in Massachusetts, is almost endless. The quartz and feldspar are commonly white, yellowish and gray; the latter not unfrequently flesh colored: the mica is very often black, but sometimes of a silver color. When the quartz prevails, the rock is easily broken, but hornblende renders it tough. The predominance of feldspar generally gives the rock a more lively white color and renders it rather easier to work. But I shall not attempt to describe particularly all the varieties of these rocks that occur in the State. An inspection of the specimens which I have collected, will at once give an idea of the kinds obtained at the principle quarries, and of numerous other varieties which I have met with in different localties. (Nos. 1271 to 1348, and 1410 to 1458.*)

The very coarse varieties of granite, which are found in some parts of the State, do by no means furnish a good building stone: indeed, some of them hardly serve for common walls. Much of the granite in the vicinity of Connecticut river is of this description; as also a considerable portion of the range which extends from Southborough to Andover; particularly along its northwestern limits. But most of the granite in the eastern part of the State, is of so fine a texture, as to answer admirably for architecture and other economical purposes. Along with sienite, it extends around Boston, running in a curvilinear direction at the distance of fifteen or twenty miles. From Cohasset to Quincy, at the southern extremity of the curve, and from the end of Cape Ann to Salem, on the north, the formation is most fully developed, and is there quarried extensively. The Quincy quarries are probably the best and most generally known; and few citizens of the State are unacquainted with the rock thence obtained, now so extensively used in Boston and elsewhere. The quantities which those quarries (or rather mountains) will furnish, are incalculably great. One railroad, as is well known, has been used for several years to convey the granite from the quarry to Neponset river, a distance of three miles. It is thought, however, that the granite has not reached its *minimum* price. Yet even now, Boston is almost as much distinguished for its granite structures, as the metropolis of the Russian Empire.

Some of the granite obtained on the north of Boston, cannot be distinguished from that of Quincy. I observed the resemblance most strongly in Danvers and Lynnfield. At the former place it is quarried, and fine blocks are obtained. Extensive quarries are also opened in the north side of Cape Ann, in Gloucester. The rock here resembles that of Quincy; but it is generally harder and of a lighter color. At these quarries no railroad (except one of a few rods in length) is necessary to transport the rock to the sea-side; since vessels can approach very near the spot. And, since the demand for this rock must increase, in our country, for many years to come, and Cape Ann is little else than a vast block of it, it seems to me that it must be regarded as a substantial treasure to that part of the State,—far more valuable than a mine of the precious metals. At Squam, in Gloucester, I was informed that blocks of granite had sometimes been split out sixty feet in length; indeed, I saw the face of a ledge from which they had been detached.

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* In all cases where numbers are included in parentheses as above, in the subsequent pages of this Report, they refer to the collection of rocks and minerals which I have deposited in the hands of the Government, and a descriptive catalogue of which is given in the Appendix.

At Fall River, in Troy, which lies upon Taunton river, are other extensive and interesting granite quarries. This granite, as the Map will show, is connected with the Quincy range above described. Yet the greater part of the granite in Plymouth and Bristol is coarser than that of Quincy and Gloucester, and more liable to decomposition. But no rock can be finer for architectural purposes than the granite of Troy; and immense quantities have been obtained from this locality. The large manufactories at Fall River are built of it, as is also Fort Adams at Newport, Rhode Island. The feldspar of this rock is a mixture of the flesh red and light green varieties; the former predominating: the quartz is light gray, and the mica, usually black. It works easily, and has a lighter and more lively appearance than Quincy granite. Blocks of this granite have been split out from fifty to sixty feet long, as the sign-post at one of the public houses at Fall River, will attest: it consists of a single block. The contiguity of this granite to water transportation, will always render it peculiarly valuable.

The granite range extending from Cohasset and Quincy, through Randolph, Stoughton, Foxborough, &c., into Rhode Island, with one interruption by graywacke, affords much valuable stone for architectural purposes; and it is wrought more or less in every town through which it passes. About two and a half miles to the west of Providence, R. I. it is quarried; also in Johnstone, five miles northwest of the city; and thence were obtained the beautiful and magnificent pillars in front of the Arcade in that place

That part of this extensive deposit of granite, which is fully developed a little south-west of Dedham, furnishes some beautiful varieties of stone. No better example can be referred to, than the elegant pillars of the Court House in Dedham. This granite is very fine grained, and so white, that at a short distance it cannot be distinguished from white marble. The pillars just named were obtained from some large bowlders near the dividing line between Dover and Medfield.

The stone used in Boston under the name of Chelmsford granite, is found in a range of this rock, not connected with the deposit that has been described above. Nor does it come from Chelmsford; but from Westford and Tyngsborough. In the latter place, it is obtained chiefly from bowlder stones; but ledges are quarried in Westford. I do not know why it has been called Chelmsford granite, unless from the fact that large quantities are carried to Lowell, (formerly a part of Chelmsford,) to be wrought. This rock is pure granite, with no hornblende; and being homogenous and compact in its texture, it furnishes an elegant stone. Good examples of it may be seen in the pillars of the United States

Bank, and in the Market House in Boston. These were from Westford.

Four miles north of Lowell, a quarry of this granite has been opened in Pelham, N. H. Blocks may be obtained from this place of any length under thirty feet. It is a very fine variety, is much used, and appears superior to the Chelmsford granite.

The Westford and Pelham granite is connected with an imperfect kind of mica slate, in which it seems to form beds, or large protruding masses. In the same mica slate at Fitchburg, a little south of the village, is a large hill of the same kind of granite. This is quarried though not extensively, on account of the little demand for the stone. This single hill, 300 feet high, and nearly a mile in circumference at its base, might furnish enough to supply the whole State for centuries. Some of it, however, is too coarse for architecture.

The manner in which the granite is usually split out at the quarries is this. A number of holes of a quadrangular form, a little more than an inch wide, and two or three inches deep, are drilled into the rock, at intervals of a few inches, in the direction in which it is wished to separate the mass. Iron wedges, having cases of sheet iron, are then driven at the same time, and with equal force, into those cavities; and so prodigious is the power thus exerted, that masses of ten, twenty, thirty, and even fifty and sixty feet long, and sometimes half as many wide, are separated. These may be subdivided in any direction desired; and it is common to see masses thus split, till their sides are less than a foot wide, and their length from ten to twenty feet. In this state they are often employed as posts for fences.

Respecting the price of the granite from these quarries that have been described, I have not been able to obtain much information. At Fitchburg, I was told that it was sold at the quarries, well dressed, at forty cents the superficial foot; and at Squam at forty-five cents.

The cost of hammering and fine dressing granite in Boston, in the style of the Tremont House, I have been credibly informed, is about thirty cents the superficial foot. Ordinary work, however, is from twenty-five to thirty cents; and not unfrequently, even as low as twenty cents.

Concord and Hallowell granite costs about fifty cents per foot in Boston; but are now little used.

Posts for store-fronts cost about thirty-four cents per foot in Boston. The Columns of the Hospital were obtained for about one dollar per foot.

To show how rapidly the price of granite has fallen, I would state on the authority of a respectable architect in Boston, that the cost of the blocks of the Quincy granite for the Bunker Hill monument, delivered at Charlestown in a rough state, was thirteen cents, three mills per foot; and the cost of the unhewn stone for the church built last year in Bowdoin street, Boston, was fifteen cents; but six years before, the rough Quincy granite, for the United States' Branch Bank, cost two dollars per foot.

I have now given an account of the most extensive and important quarries of granite and sienite in the eastern part of the State. Granite is wrought more or less, however, not merely in all the towns through which its ranges pass, but also in other places, in their vicinity; large blocks of it having been removed thither by diluvial action in former times.

Although the granite in general, in the vicinity of Connecticut river, is too coarse for architectural uses; yet in Hampshire county are several beds of a superior quality. Perhaps the best is found in Williamsburgh, a few miles from Northampton. This rock, (some of which may be seen in the front of a few buildings in Northampton,) very much resembles the granite found in the vicinity of Dedham, and yields in beauty and value to none in the State. It exists in abundance in Northampton, Whately, and Williamsburgh; but has yet been quarried only on a very limited scale.

On the east side of the Connecticut, a very beautiful sienitic granite exists in Belchertown; in which the mica, when the hornblende is wanting, is very black. It is not surpassed in elegance by any rock in the State; but it has not as yet, to my knowledge, been quarried at all. Indeed, very little real granite is employed in the middle or western parts of the State, except in a rough condition.

This sketch of the granite of Massachusetts, although brief, is sufficient to show that we have a great number of varieties, and an exhaustless quantity of this most valuable material for durable and elegant architecture. Numerous varieties not mentioned above, which have fallen under my consideration, either in ledges or loose blocks, will be found in the collection of specimens; and some of these are peculiarly beautiful. Numerous other varieties have doubtless escaped my observation. Indeed, we may safely assert, that no part of the world is better furnished with this useful and indestructible rock.

Gneiss.

This rock is commonly known under the name of granite; and, indeed, it is composed of the same materials; but in the gneiss, the structure of the rock is slaty, and it splits in one direction better than in others; yet this slaty structure is often hardly perceptible, even in wrought specimens; and hence for all architectural and economical purposes, the distinction between granite and gneiss is of small importance; though of much consequence in respect to the science of Geology.

The quarries of gneiss in Massachusetts are perhaps even more numerous than those of granite, though not in general so extensively wrought. It forms admirable building stone; and is in no respect, that I know of, inferior to granite; while the facility with which it cleaves in one direction, renders it easier to get out and dress; so that it can be afforded at a less price. Accordingly we find that a large proportion of the better class of buildings in the extensive portion of the central part of the State where this rock prevails, are underpinned by wrought blocks of it. Its fissile character also renders it an excellent material for common stone walls and flagging stones. The same property enables the quarryman to split out layers of it of almost any size, and only a few inches in thickness; and their surface is generally so even, as to require but little dressing. Hence it is very common to see such large stones of this description in front of very many of our churches and other public buildings.

In Europe gneiss seems to have been applied to few useful purposes. One of the latest geological writers in Great Britain, says that 'this schistose (slaty) body serves no particular purpose in the arts of life.'* Dr. Macculloch however mentions that the micaceous varieties are employed in building and sometimes for roofing.† This rock appears to be more perfectly developed in our own country than in Europe. There it seems chiefly to consist of the granitic variety, or of that variety not uncommon here, in which the layers are so contorted and irregular as to prevent its splitting into parallel planes.

The western part of Worcester county, and the eastern parts of Hampden, Hampshire, and Franklin counties, afford the best quarries of gneiss. That branch of the Worcester range extending into Middlesex county, and the range in Berkshire county, do not furnish so good specimens for architecture, though by no means devoid of interest in this respect.

The quarries of gneiss that are most extensively wrought, and furnish the best stone are situated in the following towns: Wilbraham, Pelham, Monson, Montague, Dudley, Milbury, Westborough, Boylston, and Uxbridge. Much of the stone at these quarries can hardly be distinguished from granite, even by the Geologist. The

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* Ure's Geology, p. 100. † Macculloch's System of Geology, Vol. 2, p. 155.

Milbury gneiss, for instance, is very much used in Worcester, and does not there present any appearance of stratification, and very little of a slaty structure: while the granite, that is quarried in the east part of Worcester, is distinctly stratified; and would probably be called gneiss by most persons, rather than the Milbury rock.

At these gneiss quarries it is easy to obtain blocks from ten to twenty feet long, which are only a few inches thick. At Dudley, I was told that narrow slabs of this rock, such as would answer for posts, or side walks, could be split out, and delivered in the centre of the town for four cents per foot.

Greenstone.

This is one of the most enduring of rocks; but it is usually so much divided by irregular seams, into small and shapeless blocks, that it is but little employed, either in the construction of houses, or walls. Its dark color, also, renders it less acceptable than granite or limestone. Still it is beginning to be used for building houses, in its unaltered state. The irregular blocks may be so laid with white mortar, especially in the Gothic style of building, as to form a picturesque and pleasing structure. The Episcopal Church, in the city of New-Haven, Conn. presents a good example of this kind of architecture.

Hornblende Slate.

I do not recollect to have seen this rock employed in Massachusetts for any useful purpose, except for the construction of common stone walls. But I have noticed some very fine samples of it in the flagging of the side walks of New-Haven, obtained, I presume, in Connecticut, from the same range that passes through Monson, Ware, &c., in Massachusetts.

Porphyry.

This term, as it employed in the arts, embraces several varieties of rock not designated by its strict geological sense. Although upon the Map, I have included in the term, only the porphyry of geologists, yet in this place, I shall describe all those compounds occurring among us, which have been denominated porphyry in the arts.

The first and most extensive of these, is the genuine feldspar porphyry, represented on the Map in large quantities in the towns of Medford, Malden, Chelsea and Lynn, on the north of Boston; and in Needham, Milton and Braintree, on the south. This is the oldest and most enduring of the porphyries, and, indeed, the hardest of rocks. Its basis is generally compact feldspar, reduced to a homogeneous paste, and of various colors; as light purple, red of various shades, brownish black, and greenish gray. The imbedded crystals are either feldspar, or quartz alone, or existing together in the same rock; and their colors are very various, though more usually white or gray. By these mixtures porphyries are produced, rivalling in beauty the best antique porphyry. This rock is polished with so great difficulty, that it is rarely used in our country, either for ornamental or useful purposes. But it would be strange if an increase of wealth and refinement should not create some demand for so elegant and enduring a rock. Whenever this shall happen, the vicinity of Boston will furnish every variety that can be desired, and in blocks large enough for any purpose. Quite a number of smoothed or polished specimens may be seen in the collection. (Nos. 1231 to 1269.)

The porphyry range on the north of Boston, is most perfect in its characters, and in the greatest abundance at any one place; although the southern range spreads over a greater extent of surface. In Lynn, and some other towns, I have observed blocks of porphyry that were brecciated—that is, they were composed of angular fragments of porphyry reunited. This furnishes a beautiful variety for polishing. (Nos. 1264 to 1269.)

Sienitic Porphyry.

When sienite contains crystals of feldspar imbedded in the mass, it is said to be porphyritic; and some varieties of this rock in the eastern part of the State are very elegant. Essex county produces some of the finest specimens, particularly Cape Ann. Sometimes the imbedded crystals of feldspar, are white, sometimes flesh-colored; and in Gloucester, I found a rock in which they were of a rich bronze color. These sienitic porphyries are extremely elegant when polished; but I am not aware that they are employed at all for ornamental purposes, in this country. (Nos. 1341 to 1346.)

Porphyritic Greenstone.

The ingredients of greenstone are often not easily distinguished from each other by the naked eye; and when, in such a case the rock contains disseminated crystals of feldspar, it becomes porphyritic. If these crystals are greenish white, and the base blackish green, the rock is the *green porphyry* of the ancients. In Dorchester, Brooklyn, and Roxbury, according to the Messrs. Danas, it occurs in rounded masses; and in small quantity, in veins, at Marblehead. But I have found it in large veins, traversing sienite at Sandy Bay, on the northeast side of Cape Ann. Large blocks might be thence obtained; and if polished, it would constitute a truly splendid ornament for the interior of a church, or a private dwelling.

If the feldspar crystals be black, or grayish black, the rock is the superb *black porphyry* of the ancients. This occurs in small beds and rolled masses in Charlestown, and in veins of greenstone, at Marblehead, according to the Messrs. Danas: but I have not met with it.

The hornblende slate in various parts of the State, but particularly in the region of the Connecticut river, is frequently porphyritic; and exceedingly resembles porphyritic greenstone; being, in fact, composed of the same ingredients; and differing only in its slaty structure, and in the more distinctly crystalline character of the hornblende. The disseminated crystals of feldspar are usually white. In Canton and Easton, they are sometimes the compact variety, yet retaining their form perfectly. A fine variety and in large quantity occurs in Heath, a specimen of which may be seen in the collection. (No. 944.)

The magnetic iron ore in Cumberland, R. I. is profusely sprinkled with crystals of feldspar; and would doubtless form no mean substitute for green or black porphyry. (No. 847.)

In Ipswich I found a bowlder of greenstone in which are imbedded numerous distinct crystalline masses of jet black Karinthin. (No. 1159.) The same rock occurs in Durham N. H, and on the western slope of the Green Mountains in Vt. But I apprehend that the color of the rock is too dark to be employed much for ornament.

Quartz Rock.

When this rock occurs pure, it can hardly be employed in architecture of any kind, on account of its breaking into fragments so extremely irregular. But when it takes a small proportion of mica into its composition, it is often divided, with mathematical precision, into layers of convenient thickness for building. The best quarry of this kind that I know of, is in the west part of Washington, Berkshire county, about three miles south-east of Pittsfield village. The layers vary in thickness from an inch, to one or two feet; thus affording materials for fine flagging stone, as also for walls and underpinning. The quantity of this rock at the quarry is very great.

Although quartz rock is usually, of all others, most easily affected by heat, yet that variety from the quarry at Washington, is remarkable for its power of resisting heat; and it is hence employed for the hearths and walls of furnaces. Prof. Dewey says that he has 'seen, this stone after it has sustained the highest heat of the furnace for months, and found its surface merely glazed by the high temperature.' It was transported to the iron works in Bennington, Vt., until a similar rock was discovered in that town. It occurs also in Williamstown. What peculiarity this rock possesses, that renders it able to resist a high temperature, I do not know.

Another valuable variety of quartz rock is found near the quarry above mentioned. But its use, as well as that of another variety in Cheshire, will be noticed subsequently.

Mica Slate.

This rock is generally more uneven or tortuous in the structure of its layers, than any rock in the State. But, like geniss, its layers are sometimes remarkable for their regularity. It then forms an admirable stone for flagging, for hearths, and for situations where there is an exposure to a moderate degree of heat. The variety that occurs in Goshen and Chesterfield, Hampshire county, is perhaps the best in the State for these purposes; and in these places, particularly in Goshen, it is quarried to a considerable extent. In some cases this rock approaches so near to argillaceous, or roof-slate, that it is employed for common gravestones. In Halifax, Vt., there is a quarry of this character; and, I believe, also in Chesterfield, Mass. Sometimes it forms excellent whetstones; and from the quarries in Enfield and Norwich, large quantities are obtained and extensively used.

Talcose Slate.

The principal value of this rock, in an economical point of view, is derived from its power of resisting high degrees of heat. The greater the proportion of talc in its composition, the more valuable is it in this respect. A very fine stone of this description, for the lining of furnaces, is quarried in Stafford, Ct., and is employed to some extent in the furnaces in Massachusetts. I do not know of any quarry of this kind in our own State; but undoubtedly such might be opened, since almost every variety of talcose slate exists here. Indeed, I am informed by the Rev. Mr. Colton, of Amherst Academy, that talcose slate, equal to that in Stafford, may be dug in Monson; and it occurs of very similar appearance in Hawley and Rowe.

In Plainfield and Hawley a variety of talcose slate occurs, in in which are disseminated numerous crystals of black hornblende. The talc is green and the quartz white, and the rock admits of a polish. Sometimes the talc almost disappears; and then we have a white base with black crystals imbedded. In short, I feel satisfied that this rock would form a tolerably good ornamental stone, if wrought into tables, urns, chimney pieces, &c., &c. But of this others can judge from the specimens which I shall place in the collection already referred to. Large blocks of it may be obtained, which would be very firm throughout. (Nos. 837. 838. 839.)

Limestone.

Next to granite and gneiss, this is the most valuable rock in the State. Little advantage is derived from it, however, by any part of the State except Berkshire county. Small beds of it do, indeed, exist in the eastern part of the State; but they rarely furnish blocks sufficiently large and sound, to be wrought into marble. And on account of the high price of wood in the vicinity of Boston, it cannot be burnt into quick lime, so as to be afforded at a less price than the lime brought from Maine. In many places, however, it continues still to be burnt. Judging from the appearance of the quarries, I should suppose that Bolton furnishes a greater quantity of lime at present, than any other locality. The stone here is mostly crystalline, and white, although it is apt to be much mixed, as it is at every other locality in the eastern part of the State, with a variety of minerals, that much injure it for lime. Beds of this limestone occur at Newbury, Bolton, Boxborough, Acton, Littleton, Carlisle, Chelmsford, and Stoneham. That in Stoneham is peculiarly fine; and could large blocks of it be obtained, free from fissures and foreign minerals, it would undoubtedly answer well for satuary. When there shall be a greater demand for a stone of this description, perhaps a farther exploration will bring to light, at this quarry, many larger and sounder pieces.

On the south of Boston, at Walpole, is a bed of limestone of a gray color and probably somewhat impure. It would, however, make good lime: and indeed it was burnt in considerable quantity some years ago. But until the lime from Maine and Rhode Island, shall sell at a higher price, this cannot be profitably prepared. It must be gratifying, however, to the inhabitants of the eastern section of the State, to know that such abundant sources of this valuable rock are within their reach, should their present means of supply be cut off.

The limestone quarries in Smithfield, Rhode Island, are so situated as to be of great importance to Massachusetts, being accessible to a large portion of the southeastern part of our State, and lying close to the Blackstone canal. The limestone here is white and granular; very much resembling that in the towns northwest of Boston,—especially that in Stoneham. It occurs in two principal beds, about two miles apart. I was told by an agent of one of the companies, which own this limestone, that not far from twenty thousand casks of lime, containing from thirty eight to forty gallons each, and worth nearly two dollars each, are annually prepared in the whole town.

Several beds of limestone may be seen on the Map in the eastern part of the range of mica slate in Franklin county, west side of the Connecticut, in the towns of Whately, Conway, Ashfield, Colerain, &c. But this limestone is quite impure, and is not generally distinguished, by the inhabitants of those towns, from the mica slate. It becomes an interesting enquiry, to those residing in the valley of the Connecticut, where quick lime is more expensive than in any other part of the State, whether this stone can be profitably converted into mortar. Very few attempts have yet been made to burn it, and those obviously quite unsatisfactory. Those who made these attempts probably thought that the stone, after burning, would slack with as much energp and readiness as pure quick lime; and because the process went on slowly and feebly, they have inferred that the lime would be of no value. At least, I know this to have been the conclusion in one instance, in which I had procured the burning of a considerable quantity of this limestone, in a regular lime kiln. But the mason, not seeing it slack briskly, did not think it necessary to apprize me of what he was doing, and mixed it with other lime, and defeated the whole experiment. I have, however, burnt a few pounds of this stone in a common chemical furnace, and found it to form a very excellent mortar; although requiring less sand than pure lime. Bricks cemented with it two or three years since, still remain as firmly united as ever.

This limestone contains a large proportion of silex, which, on burning, becomes a harsh sand. Wishing to know how much of pure carbonate of lime is contained in it, I powdered and dissolved portions of it, from different localities, in muriatic acid; and the results were as follows:

1. Purest variety from Whately; 100 parts contain carbonate of lime 78; residuum (chiefly sand) 22 parts.

2. Compact variety from Conway; carbonate of lime 58 parts; siliceous residuum 42 parts.

3. Poorest from Whately; carbonate of lime 67 parts; siliceous residuum 33 parts.

4. From Southampton; carbonate of lime 40 parts; siliceous matter 60 parts.

I tried some specimens of our best limestones in the same manner, with the following results:

1. Gray limestone from New Marlborough; carbonate of lime, 98 parts; residuum (chiefly mica) 2 parts.

2. Gray limestone from Walpole; carbonate of lime 92 parts; residuum 8 parts.

3. White crystalline, from Boxborough; carbonate of lime, 99 parts; residuum 1 part.

It is my decided opinion that the limestone, described above, in the primitive region of the Connecticut valley, may be usefully employed either for mortar, or for spreading upon the soil. The beds of it are quite numerous in all the towns where they are occasionally marked. I think, however, that the best variety occurs in Whately, where, should it ever come into use, on the north line of the town, is a hill large enough to supply the whole valley of the Connecticut for centuries. This locality is favorably situated for working, so as to furnish that valley; being not more than two or three miles from the Connecticut, and the whole distance nearly level. I cannot but hope that the attention of some enterprizing gentleman may be directed to this subject; and should he succeed in preparing even tolerable lime from this rock, he would confer a great favor upon the inhabitants of that section of the State.

A large portion of the limestone in Berkshire is excellent for burning into quick lime: and even in several towns where none of the rock occurs in ledges, so abundant are the loose masses, transported thither by a current of water in early times, that it is burnt in considerable quantities. This is the case in Windsor, Peru, &c., from whence lime is transported in wagons to the valley of the Connecticut.

Probably, however, a still larger proportion of the lime used in that valley, particularly in its northern part, is brought from Whitingham, Vt., a town lying directly north of Rowe in Franklin county. This limestone is white and crystalline, and it exists in large quantities. It approaches within a few rods of the Massachusetts line, and may even pass over it in some places.

Two interesting beds of limestone of a peculiar character, have been discovered, within a few years, in the valley of the Connecticut, at West Springfield, a few miles south of Mount Tom. It is chiefly the fetid limestone, though mixed with various impurities. But it answers well, and that too on account of its impurity, for water proof cement, or mortar that will harden under water. It was used on the Farmington canal, particularly in the construction of the acqueduct across Westfield river. The same rock occurs at Southington and Middletown, Ct., and I doubt not may be found in many other places, along the river, associated with the new red sandstone. I am not aware that fetid limestone has ever before been used as a water proof cement. In Europe, and I believe in New York, the blue argillaceous limestone is employed. Pure lime, however, will answer the purpose, if it be mixed with puzzolana or tarras. The former of these substances is decomposing lava, and the latter decomposing basalt. I doubt not but that decomposing greenstone will answer as well; and if so, it can be found in abundance on the north of Boston, and near Connecticut river, particularly in Greenfield and Deerfield. Lava, basalt, and greenstone, are so much alike, that I think the latter well worth a trial. Indeed, if I recollect aright, the experiment has already been successfully tried in New Haven, Ct.

As the Springfield limestone is abundant, it would be very desirable to have it tried upon some land in the vicinity: for, if it answers well in agriculture, (and I see no reason why it may not,) it might prove an invaluable acquisition to the farming interest of the Connecticut valley.

Postscript.—Discovery of good Limestone in the valley of the Connecticut.

After the preceding remarks upon the limestones of Massachusetts were written, I received specimens, through the kindness of Mr. Henry W. Cushman, of crystalline carbonate of lime, found in Bernardston, near the centre of the town, and a short distance from the stage road from Greenfield to Brattleborough, Vt. I immediately visited the spot, and found, indeed, a large bed of limestone, connected with quartz rock, or argillaceous slate, not less than fifty rods long, and three or four rods thick, appearing at the summit of a hill, and dipping nearly southeast at a small angle. In the limestone is a large bed of iron ore, which was dug forty or fifty years since, and with the limestone sent to Winchester, N. H., to be smelted. Neither the limestone, nor the iron have been thought worthy of attention since. But a kiln of the former has recently been burnt, and found to produce a very strong lime, although of a rather darker color than the white limestones generally produce.* This results from a quantity of the hydrate of iron, which penetrates the seams of the rock: but this does not injure the stone for mortar, and probably even makes it more valuable. The bed is only three or four miles from Connecticut river and on the bank of Fall river, a small stream that empties into the Connecticut. By going to Cheapside, in Deerfield,

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*April 1334. Large quantities of this limestone have been burnt more recently and it is getting into use extensively. If more kilns were in operation, probably there would be a demand for the products. I am informed also that an effort is now making by an intelligent gentleman to smelt the iron ore.

(eight miles,) over a level and excellent road, water communication with the whole valley of the Connecticut, will be reached. I have little doubt, that if this limestone should be extensively burnt, it will reduce the value of quicklime in that valley, from twenty five to fifty per cent.: a benefit superior to any that could be conferred by the discovery of a gold or silver mine.

I dissolved some of this lime, in diluted nitric acid, to see if it contains magnesia. The solution was not milky, and therefore no magnesia was present. I also dissolved 100 grains in muriatic acid, and the siliceous residuum was only a single grain: the 99 grains are probably chiefly carbonate of lime; although whatever amount of oxide of iron was present, would also be dissolved.*

Marble.

The limestone of Berkshire is best known for the fine marble which it produces. It is all of that variety denominated primitive marble. It is always more or less crystalline, sometimes very coarsely so. The prevailing color is white; and this is the variety most extensively wrought. Some varieties are snow white, and admit of a very fine polish. From this pure white, the color changes by imperceptible gradations to gray, and dove color. These varieties form delicate marbles. But probably most persons would say that the clouded variety, where the white and the gray are fantastically mixed, is most elegant.

More or less marble is quarried in almost every town of Berkshire county, except a few on its eastern side. But the towns where it is most extensively wrought are West Stockbridge, Lanesborough, New Ashford, Sheffield, New Marlborough and Adams. A few years since, Prof. Dewey stated the amount of marble annually furnished by West Stockbridge, to be sixteen thousand square feet, valued at $25,000 to $30,000; the amount at Lanesborough, seven thousand feet; value $10,000; and in Sheffield, to the value of $8,000. In all the county, the annual value of marble was estimated to be more than $40,000. Still more recently there were in operation in West Stockbridge, for sawing marble, nine mills, moved by water power; and two hundred hands were employed. From twelve to fifteen quarries had been opened; and in 1827, about two thousand seven hundred tons of marble were exported from this town. The marble used in building the city hall in New York City was chiefly from this town. A part of the marble in the state house in Boston, was from the same place. In 1828, a charge of two hundred and four pounds of powder was put into the rock in one of the West Stockbridge quarries, and a block from fifty to sixty feet square and eight feet thick, was raised and as much more loosened.

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* Still more recently a bed of crystalline limestone has been found in the north west part of Blanford, which will be described in the third part of my Report. I believe that as yet no attempt has been made to burn this rock into quicklime.

The Lanesborough marble is of a superior quality, and a good sample of it may be seen in the capitol at Albany. The New Ashford quarries furnish a marble of the same kind; and several quarries are opened. Only one mill is there erected for sawing it into slabs. A mill of the same kind is in operation in Lenox, and another at New Marlborough. In Sheffield, three quarries are opened. In Alford, two. In Egremont, a bed of marble limestone extends nearly through the town.

There can be no doubt that greater facilities for the transportation of the Berkshire marble—such as a rail road to the Hudson—would greatly increase the demand for it, by reducing its price. Such facilities will undoubtedly be provided at some future time. For as a country grows older, and increases in wealth and refinement, its valuable and ornamental minerals and rocks will be more sought after and used. The inhabitants of Berkshire cannot, therefore, but regard their inexhaustible deposits of marble and common limestone, as a rich treasure to themselves, and an invaluable legacy to their posterity.

The limestone of Smithfield, R. I., and of Stoneham, in this State, bears a close resemblance to that which produces the celebrated Carara marble of Italy. But as yet, few blocks have been obtained at either of these localities, large enough and free enough from fissures, to be used for statuary.

Serpentine.

In richness and variety of colors, this rock exceeds all others; and is, therefore, eminently suited for ornamental sculpture and architecture. The prevailing color is green, of different shades, spotted or clouded, or veined with other colors; and hence its name, from its spotted and striped appearance, bearing a resemblance to the skins of some serpents. In hardness, it varies very much; being in some instances very hard, and in others, as easily wrought as marble.

This rock exists in Massachusetts in great abundance, particularly in the Alpine part of the State, or in the Hoosic mountain range. The most extensive bed occurs in Middlefield, in the southern part of the town. This bed cannot be less than a quarter of a mile in breath, and five or six miles long. The colors of the rock are various, and its hardness unequal. If wrought, it might supply the whole world. It yields both the precious and common varieties. There is another bed in the same town, associated with steatite or soapstone. In the west part of Westfield is found another extensive bed of this rock, extending into Russell, of a much darker color, and containing green talc. This has been used in a few instances for ornamental architecture, and has a rich appearance when wrought. Three beds of serpentine are found in Blanford, and another in Pelham, in the southwest part of the town. The color of this last is quite dark, and the quantity of the talc is considerably large. A large bed occurs in connection with soapstone, on the north side of Deerfield river, in Zoar, near the turnpike from Greenfield to Williamstown. Specimens from this place resemble those from the celebrated localities of this rock at Zobilitz, in Saxony. Serpentine also exists at Windsor in two beds; and there is an immense bed of it in Marlborough, and another still larger in Cavendish; as also in several other towns in the lower part of Vermont.

The only locality of this rock in the eastern part of the State, that I know of, is in Newbury, two and a half miles south of Newburyport, near the Boston turnpike, at an abandoned lime quarry. The precious, or noble serpentine is found here very beautiful, and very much resembling that of Cornwall in England. No serpentine in the State will compare in beauty with this; but perhaps if the other beds were explored by blasting, they would put on a different aspect. (Nos. 870 to 873.) Serpentine also exists at Newport, R. I., of a dark color and compact texture.

Serpentine and limestone, irregularly mixed, form the noted *Verd Antique* marble. Such a mixture occurs at Becket, according to Prof. Dewey, in a bed of gneiss. The limestone is also sometimes mingled with the serpentine at Newbury and at Westfield. I cannot see why these varieties are not Verd Antique, though I would not decide very confidently. At New Haven and Milford, Ct., extensive quarries of Verd Antique marble have been opened. It is the Ophicalce grenue, of Brongniart.

Considering the extent and variety of serpentine in Massachusetts, it seems not a little surprising that no efforts, or next to none, have been made to use it for ornamental or architectural purposes. In Europe, it is employed for trinkets, vases, boxes, chimney pieces, and even columns of large size. In Spain, it is said that churches and palaces abound with columns of this description. If ever the serpentine of Massachusetts shall be extensively wrought, I doubt not that specimens will be obtained, rivalling the finest varieties of Europe. It is not at present easy to obtain hand specimens, that shall give a fair representation of this rock, because it is injured to a considerable depth, from the surface exposure.

Steatite, or Soapstone.

This is the softest of all the rocks employed in architecture. This property, rendering it easy to be sawed or cut without injuring an edge tool, and its greasy or soapy feel, are such striking characteristics of this rock, that most people are acquainted with it. It is sometimes called *potstone*, and sometimes in this country, *freestone.*

Next to the ease with which it may be wrought, its great power in resisting heat, is the most valuable property of this rock. Hence it is extensively employed for fire places and furnaces.

It is also turned into crucibles and small furnaces for culinary use. Inkstands are made of it in great numbers, and various other articles. As it hardens in the fire, it is used in Europe for imitating engraved gems. It has been employed in various countries as a substitute for soap and fuller's earth. Spanish and French chalk are varieties of steatite. Savage nations are said to mitigate hunger by eating this soft mineral; as however it contains nothing alimentary, it can act only as a palliative of hunger.* Those varieties that are most infusible are employed in England extensively in the manufacture of porcelain.

Steatite, like serpentine, usually occurs in beds of no great extent. They are numerous in Massachusetts, and very commonly they are associated with serpentine, or in the vicinity of it. This is the case in the northeast part of Middlefield, where one of the finest beds of it, in the State, is found; although it contains small masses of *bitter spar*, which renders it less easy to work. But this quarry has been explored more extensively than any other in the State; and the blocks transported to Northampton, and even to Boston. In Windsor are not less than three beds of this rock, from which the New Lebanon Shakers obtain it, for converting into inkstands. I was told that a bed of it exists in Cheshire. Another occurs in Savoy; one in Hinsdale; one also in Blanford, which is wrought and produces an excellent stone. Two beds occur in Granville, which I have not visited. Another is opened in Zoar, where are two distinct varieties, one nearly white, another of a deep green. In Rowe is another quarry, where these two varieties are equally distinct. At the two last named localities, however, the rock is distinctly green and white talc; and indeed, the two minerals (talc and steatite) are probably in every case identical.

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* See Brongniart's Mineralogy.

On the east side of Connecticut river are several beds of this rock, more or less quarried in every instance; but in general not explored deep enough to develope the rock in its unaltered character; for the air and moisture generally affect it for several feet deep. In the south part of Shutesbury is one bed; in the southwest part of Wendell another; and two miles east of the centre of New Salem, a third. The quality of the rock at these places, is not as good as that west of the river; though it has scarcely been explored at all, at the localities above mentioned.

In Groton is a bed of soapstone on which considerable labor has been expended. Its width appears to be 10 or 12 feet, and it descends into the earth towards the southeast; dipping about 30°, and lying between layers of mica slate. It is not of the best quality, being somewhat too hard; yet its proximity to Boston, Newburyport, and Salem, will probably render it an object of importance.

A bed of soapstone has recently been discovered in Worcester; and the specimens thence obtained, (Nos. 403 and 1548,) show it to be more elegant in appearance than any other in the State. The bed (which I have not personally examined,) has yet (1834,) been penetrated only about five feet: but should it prove extensive, its situation so near the Blackstone Canal, will render it an object of no little importance.

In the states adjoining Massachusetts, and not many miles from its limits, several extensive and valuable quarries of soapstone have been opened. In Vermont they occur at Marlborough, Windham, and Grafton. In New-Hampshire, very fine steatite is found at Francestown. In Connecticut, a bed has been wrought in Somers. The Grafton steatite is employed extensively and successfully for aqueducts: the joints being connected by sheet lead. A bed of this rock exists in Smithfield, R. I., although it is not wrought; there are beds also in several other places in that state.

From the preceding statements it seems that in this State, and contiguous to it, immense quantities, and every variety of steatite exist. As yet, however, the working of it has hardly commenced; although almost every man is aware of the value of this rock; and there are few who do not sometimes stand in the need of it for economical purposes. As the facilities for transportation are multiplied, and particularly in the mountainous part of the State, its use will undoubtedly be greatly extended. At present, I believe, the shops in Boston are supplied from Vermont and New Hampshire.

Graywacke.

For the most part, this rock furnishes a coarse stone only fitted for a common wall; but sometimes its stratification is so regular, and its grains are so fine, that it answers well for underpinning, step-stones, &c. It is quarried I believe in Brighton, and some other towns in the vicinity of Boston. At Pawtucket, on the Rhode Island side of the river, is an extensive quarry of a fine grained and slaty variety, which I should judge would form a good flagging stone; and immense quantities have been taken away for this object and for other purposes. On Canonicut island in that state, is also a valuable quarry of this rock.

Graywacke is sometimes beautifully amygdaloidal; that is, it contains numerous rounded or almond shaped nodules of some other mineral. In these instances, however, the base of the rock is rather *Wacke*, than graywacke. This wacke (which resembles indurated clay,) often forms the cement of graywacke. In Brighton it is of a reddish color, while the imbedded nodules are sometimes white, and sometimes white feldspar with epidote, which is of a lively green color; and these substances are not only in rounded masses, but in veins of irregular shape. The rock is hard and admits an imperfect polish. It then resembles porphyry and is elegant. A fine example of this may be seen at the residence of H. A. S. Dearborn, Esq. in Roxbury, forming a pedestal for the bust of his father. It is only slightly polished, but would generally be mistaken for porphyry.

A similar amygdaloid occurs in Brookline, Newton and Needham. A variety still more beautiful is found in Hingham. The color of the base is chocolate red; and the nodules are red, green and white. I do not know whether large blocks can be got out.

I think upon the whole, however, that the finest amygdaloid occurs in Saugus, on the hill a few rods east of the meeting house. The base is a pleasant green, and the nodules white compact feldspar, generally spherical, and thickly interspersed. I have little doubt that large blocks can be obtained at this locality; but as the base is softer than the nodules, it can be only imperfectly polished.

Argillaceous Slate.

A more common name for this rock, at least for the most useful variety of it, is *roofslate;* because it is used for forming the roofs of houses. I have been inclined sometimes to regard the ranges in Quincy, Watertown, Charlestown, and Chelsea, as a fine grained variety of graywacke; but this question may be more properly considered in the scientific part of my Report. At any rate, this rock, in the towns above mentioned, does not split into layers sufficiently thin for roofing. But it is valuable for gravestones, the covering of drains, flagging stones, &c.; and for these purposes it is extensively wrought in Quincy, Charlestown, &c.

Novaculite.

This is a variety of argillaceous slate which is known in the arts under the name of hone, oil stone, turkey stone, and whetstone. It is in beds of argillaceous slate in Charlestown, Malden and Quincy. It is not, however, of a very good quality; and I am not aware of its being used for hones, or even for whetstones: although it might answer the purpose, if better materials could not be found elsewhere. M. Godon, in his account of the geology of Boston and vicinity, says that a compact feldspar is found there perfectly analagous to the turkey stone. I have found a variety of this mineral in Newbury, which I apprehend, corresponds with that described by this writer, and a specimen may be seen in the collection; but no fair trial that I know of has been made to employ this stone as a hone. (No. 1206.)

Roof Slate in Worcester County.

The range of slate exhibited on the Map in the towns of Boylston, Lancaster, Harvard, Shirley and Pepperell, is associated with the peculiar mica slate that contains the Worcester coal. It answers for roofing in some parts of the bed and has been quarried for this purpose in Lancaster. It has been wrought considerably in Harvard and Pepperell for gravestones; and is transported a considerable distance for this purpose. The stratum is narrower near the north line of the State; but I have found no time to ascertain how far it extends into New Hampshire.

Connecticut River Slate.

Although a large part of Bernardston is represented as composed of this slate, yet its characters are not perfectly developed, till we pass into Vermont. In Guilford, Brattleborough, Dummerston, and even 50 or 60 miles farther north, it produces an excellent material for roofs, writing slates, &c.; and extensive quarries are opened in it in those towns. The best slate used in Massachusetts probably comes from this range. In Bernardston it is quarried to some extent for gravestones.

Berkshire Slate.

The mica slate of the western section of the State, passes gradually into roofslate, but in most instances the characters of the latter are not very perfectly exhibited, until we have entered New York. There, however, in Hoosic, and other towns, it is quarried extensively for roofing; and the western part of Massachusetts is always sure of a supply of this valuable material from that quarter if not within its own limits.

Graphic Slate.

This occurs in small quantities, along with the argillaceous slate, in Lanesborough and Williamstown; also abundantly in Bennington, Vt. Prof. Dewey, from whose account I derive this fact, does not state whether it is pure enough to be employed by artificers for drawing lines, and for crayons; uses to which this mineral has been applied in other countries.

New Red Sandstone.

This rock occurs in Massachusetts, only in the vicinity of Connecticut river; along which, on both sides, ranges extend from Middletown, Ct. to Vermont. It affords large quantities of good stone for building and other purposes. Some of the numerous varieties of this rock are slaty; and either of a red, gray, or black color. These varieties furnish good flagging stones; and the side walks of all the principal places along the river, are chiefly covered by them. In the more common varieties, the strata are from six inches to two feet or more in thickness: and for the most part the color is red, though sometimes gray. From these thicker strata is obtained most of the rock of this formation used in architecture. The most delicate variety occurs in Longmeadow and Wilbraham. It consists simply of an almost blood red sand, cemented probably by iron. It is remarkably uniform in its color and composition; and forms a beautiful and most valuable building stone; though liable to be easily injured and sometimes disintegrating by exposure. The quantity of this rock is inexhaustible, and it occurs only from three to five miles from Connecticut river; the intervening region being nearly level. A great number of quarries are now explored; but I have no means of determining how great is the demand for the stone. The celebrated Chatham quarries, on the banks of the Connecticut river, in Connecticut, are opened in the same kind of rock, although a coarser variety.

Another variety of the new red sandstone, quarried in many places in Massachusetts and Connecticut, is coarser than the Longmeadow stone; but being harder, it is more enduring, though less elegant. This variety is quarried extensively for the Farmington Canal, in the sandstone range south of Mount Tom in West

Springfield. A gray and rather coarse variety is used in some places, e. g. in Granby, Mass. This indeed, with the other varieties mentioned above, forms excellent underpinning, door and window caps, and foundations, and door steps; and like the Berkshire marble, they are sometimes wrought into sinks and other similar articles. The ease with which the rocks of this formation are wrought, forms a great recommendation; and, were they as enduring as gneiss and granite, these latter rocks would soon be neglected.

Tertiary Formations.

I suspect there are are only two varieties of these formations in Massachusetts; one developed most perfectly in the west part of Martha's Vineyard, and the other, and the most extensive, along the Connecticut river, although common in limited patches all over the State. Neither of these formations furnishes stones sufficiently firm for architectural purposes, although in a few instances, I have observed limited beds of the clay, sand and pebbles, that compose these formations, to be in a state of consolidation. Nearly all our clays, however, are in the tertiary formations, and these are so important in an economical point of view, as to demand a particular description.

Porcelain Clay.

This is the purest of all the clays, and is the only one employed in the manufacture of porcelain, or China ware. It results from the decomposition of granite; and hence we might expect to find it in Massachusetts; since we abound so much in granite. As, however, the manufacture of this ware has but recently been introduced into this country, little effort has been made to discover this clay. It has been announced, as existing in several towns in the State, although the bed in Savoy, described by Prof. Dewey, in his account of the geology of Berkshire, is probably the only one known that merits a notice in this Report. It is said to constitute a layer three feet thick, and of unknown extent, several feet below the surface. It contains coarse particles of quartz, which can, however, be separated by sifting. It resembles the porcelain clay of Monkton, Vt., which is regarded as of a good quality. It forms a very cohesive white paste, and crucibles made from it, and burned in a common fire, were sonorous when struck. A similar clay is said to occur in large quantity in Canaan, Ct.

A part of the extensive clay beds on Martha's Vineyard, appears to be porcelain clay; especially in Chilmark: though a large proportion of mica is mixed with it.

Potter's Clay.

This is the clay so extensively employed for common pottery, pipes, tiles, and bricks. And fortunately it is found on almost every square mile in the State. We have two quite distinct varieties. The purest, sometimes called pipe clay, is found almost exclusively on Martha's Vineyard. This is white, and contains usually so little iron, that when burnt, it becomes still whiter, and will resist a high degree of heat. Hence it is employed for making what are called fire bricks, which are used for lining furnaces. White pottery is also made from it. But the more common clay turns red on burning, in consequence of the oxide of iron in it; and this renders it much easier to be melted by the heat, and consequently diminishes its value. It is of immense value, however, to the State; because good bricks may be made from it; and because it exists so abundantly in almost every town. The same tertiary formation that supplies clay so plentifully, yields an abundance of sand for the mortar by which they must be cemented. This sand, however, is generally rather fine; and I am inclined to believe, from all that I can learn, that our mortar is generally prepared from sand that is too fine.

Substitute for Fuller's Earth.

The common clay in the Connecticut valley, has recently been employed in Northampton in the place of fuller's earth, in cleansing cloth. A considerable quantity of it has also been sent down the river, for use in other places. This clay is fine grained, and when dry, adheres strongly to the tongue. It is said to answer exceedingly well in the place of fuller's earth; on this point however, I have my information at second hand. A clay of precisely the same character has recently been put into my hands from Leominster, where it occurs in alternating layers with sand. Some of the sand of this tertiary formation, especially in the gneiss region, is of a delicate white color and quite pure. In some cases, when its finest particles are mixed with clay, it will answer very well for giving a polish to brass and other metals. This variety is found abundantly in Shutesbury. (No. 2.)

Clay used in the Manufacture of Alum.

The white clay of Martha's Vineyard, is employed extensively in the manufacture of alum, in Salem; by the process of Chaptal, I suppose; although the details are, I believe, kept secret. By his method, sulphur and nitre are burnt in a chamber with the clay, which, after a considerable time, is lixiviated, and the ley evaporated. There is indeed, a variety of clay, which contains sulphur, that will produce alum without the addition of other materials; but I cannot believe that from the Vineyard to be of this description. At any rate, the alum which the Salem company produce, is of a good quality, and is made in large quantities. They formerly obtained their clay from Gay Head; but they now procure it of a better quality from the west side of the island, in Chilmark.

Clay as a Manure.

Writers on agriculture, speak of clay as next in value to marl, for manuring light and sandy lands; and I cannot but think that our farmers have yet something to learn on this subject. Marl, they cannot procure but at a great expense; but clay is usually at hand, and we have very much of the land which it will help. Yet I am not aware that in any instance the experiment has been thoroughly made.

Marl.

Marl for our farmers, scarcely exists in the State, except in a few places in Berkshire county, where it is of little use, because the soil already contains so much calcareous matter. It is said to have been found in Lancaster, but whether in large or small quantities, is not stated. Judging from the nature of the surrounding country, I venture to predict that it will not be found there in abundance. In Duxbury also, it occurs in considerable quantity. In Pittsfield, is a bed of earthy marl, but not extensive. It is found more abundantly, it is said, in Lenox; and it exists also in Williamstown.

Peat.

This useful substance must be regarded as alluvial in its character, since the process of its formation is now going on. It results chiefly from mosses and other plants, more or less decayed. In the eastern part of the State, it is found in great quantities. West of Worcester, it has scarcely been sought after, on account of the comparative abundance of wood. It will probably, however, never be found so abundantly in the western part of the State, as in the eastern. I have ascertained the existence of peat in the following towns, and do not doubt that it occurs in many others. There are two varieties; the fibrous and the compact. In the former, the moss, turf, and roots out of which peat is formed, have not lost their fibrous structure: but in the latter, they are converted into a compact and nearly homogeneous mass.

The fibrous and compact varieties probably exist at nearly every locality. I am sure of their occurrence in Cambridge, Newton and Lexington; and in large quantities. Peat is abundant in Seekonk, Uxbridge, Cohasset, Duxbury, Hingham, Medfield, Walpole, Wrentham, Dover, Framingham, Sudbury, Topsfield, Ipswich, and Nantucket.

It exists and has been dug in greater or less quantities in Pittsfield, Hadley, Leverett, Shrewsbury, Lancaster, Southborough, Hopkinton, Medway, Halifax, Stoughton, Boylston, Reading, Milton, Needham, Concord, Billerica, Bedford, Waltham, Watertown, Acton, Wilmington, Danvers, Chelmsford, Hamilton, and in nearly all the towns in Barnstable county; certainly in Yarmouth, Brewster, Orleans, Eastham, Wellfleet, and Truro. I have marked on the Map, only the most important localities.

The value of peat for fuel, is generally known; but I apprehend that it is not generally known that a still more important use may be made of it in agriculture. Peat swamps in Massachusetts are commonly surrounded by light and poor land. While the swamp itself contains too much vegetable matter, imperfectly decomposed, the land around it contains too little. All that is needed, therefore, is to employ the excess of the one, to supply the deficiency of the other. Hence, as an English writer remarks, 'peat or vegetable matter, should be carried from the peat moss to the poor soil, and the surface mould from the poor soil to the peat moss.' The peat ought indeed to be converted into manure, by lying awhile in a barn yard, or by mixing lime, or other substance with it; and there are particular directions to be observed as to the whole process, which this is not the proper place to explain. But they can be learned in works on agriculture; and whoever undertakes thus to make use of peat, without learning the results of enlightened experience on the subject, will probably fail in his object. But since great benefit has been derived from the use of peat as a manure, in England and Ireland, no reason can be assigned why it may not thus be applied in this country with equal success.

I cannot but regard the existence of so large quantities of peat, on Cape Cod and Nantucket, as a great blessing to the inhabitants. Yet from the little of it, which I observed to be dug there, I am apprehensive they do not realize its value. Most of the soil in those counties is precisely of that kind, which needs the admixture of much vegetable matter. If the peat swamps could be drained, and after the removal of a portion of the peat, be covered with lighter and warmer soil, but few years would elapse before they would become fine grass plats; while the sandy and more elevated land, enriched by the peat, would produce large crops of Indian corn, rye, and other vegetables. That this is not mere hypothesis, has been demonstrated on a small scale, at least upon one farm, that of the Hon. John Reed, of Yarmouth. Since the inhabitants of Cape Cod are beginning to turn their attention more and more to the cultivation of the soil, may we not expect that such a transformation will ere long be common.

A few other mineral substances, interesting in an economical point of view, may perhaps be appropriately noticed in this place.

1. *Granular Quartz and Sand for the Manufacture of Glass.*

From some unknown cause, the granular quartz in Cheshire, Berkshire county, is so much disintegated, that it easily crumbles into a beautiful white sand. This forms a good material for glass, and has been employed for this purpose a number of years; formerly in Cheshire and Warwick, Mass., and in Utica, N. Y.; and at present in Keene, N. H. It answers well for crown and cylinder glass. The quantity is inexhaustible. It is sold at the road, one mile from the bed, at 6 1-4 cents per bushel. The sand is employed extensively in Berkshire in the process of sawing marble.

I am inclined to believe that some of the sand associated with the tertiary and diluvial formations in the State, particularly in the gneiss region, is pure enough to be employed in the manufacture of coarse kinds of glass: such for instance as is found in Pelham and Leominster. The purest and coarsest variety, however, that I have met with, forms the shores of Lock's Pond, in the northwest part of Shutesbury. Similar sand, I believe, is used for glass making in the eastern part of Connecticut. The Shutesbury sand has been recently employed with success as a substitute for smalt, upon doors exposed to depredations from penknives and pencils.

When examining the milk white quartz, that exists in mountain masses in the east part of Cumberland, R. I. the enquiry forced itself upon my attention, whether it might not be employed in the manufacture of glass? Those particularly acquainted with that manufacture, can, however, judge better of this matter than myself.

2. *Buhrstone.*

In the same hill that furnishes the fine stratified quartz rock for architectural purposes, in Washington, three miles from Pittsfield, a porous quartz is found, which greatly resembles, and is used instead of buhrstone, for millstones. Whether geologists would allow it to be real buhrstone, may admit of doubt; since it is unquestionably a rock of primitive formation; whereas the real Paris buhrstone, is a member of the tertiary formation. But in an economical point of view, this question is of little importance, since the rock seems to answer nearly all the purposes of buhrstone so well that it is employed somewhat extensively for millstones. These are manufactured near the ledge, and are sold for seventy or eighty dollars each. I am told that they answer well, especially for the coarser kinds of grain. I should presume that the only difficulty would lie in their being less tough than the genuine buhrstone. The quantity at the ledge is inexhaustible.

Sometimes our citizens employ the finer and more compact varieties of granite for millstones. I have seen even a coarse *conglomerate*, or *puddingstone*, used for this purpose. And while upon this subject, I cannot but express my surprise that no attempt has been made to employ our greenstone, and other hornblende rocks, for millstones. In Great Britain, basalt has been, within a few years, used for this purpose, and found even superior to the French buhrstone; and our greenstone is only a variety of the same rock; indeed, some of our greenstone cannot be distinguished, by the eye, from the European basalt. It is generally extremely compact and tough; and although its preparation might require a little more labor than the buhrstone, yet it would doubtless last enough longer amply to pay for the additional labor. In the vicinity of Boston and in the Connecticut valley, as may be seen on the Map, greenstone exists in great quantities. It also occurs in small beds throughout the whole extent of the gneiss region; and of a kind, which I should suppose from its appearance, would answer the purpose even better than that of the extensive ranges above mentioned.

Coal.

Of this mineral, the object of so much interest in every civilized country, there are found three distinct species; all of which are sometimes employed as fuel. The most common in Europe, which is there considered the best, is the bituminous coal, or that containing bitumen. This burns readily with a yellow or white flame. A second species is the anthracite, or *stone coal;* which, is generally described as burning without flame, because destitute of bitumen. The anthracites of this country, however, burn with the flame that results from the combustion of hydrogen; this gas existing in a state of combination, either with the carbon, or in the water which the anthracite contains; and it is liberated by the heat. The great difficulty in the use of anthracite, consists in igniting it: a difficulty which has almost disappeared before the ingenuity of our countrymen. In Europe, anthracite has been described as of little value: with the exception, perhaps, of Killkenny coal. But our anthracite is either of a quality superior to the European, or we have learned better methods of employing it. All the coal obtained from the inexhaustible beds of that mineral along the Susquehannah, Lehigh, and Schuylkill rivers, in Pennsylvania, is anthracite; and wherever it is skillfully used, I believe it is decidedly preferred to the best bituminous coals of England, or the United States. The coal from Rhode Island, (chiefly from Portsmouth as the north end of the Island) is also anthracite. The Worcester coal belongs to the same species: indeed, every enlightened man in this country now regards our anthracite as a great national blessing. But in Great Britian, some of their geological writers speak of the anthracites found in Ireland and on the European continent, as 'carbonaceous matters that can never be profitably worked, so as to become objects of statistical interest.'—(Ure.) And Mr. Conybeare, in his admirable view of the English coal formations, speaks of the deposit of bituminous coal, as 'the only one capable of being applied to purposes of extensive utility, which appears to exist in the whole geological series.'

A third sort of coal is commonly enumerated, called *lignite;* consisting of wood partially carbonized, and still retaining its form, more or less distinctly. All the kinds of coal that have been mentioned, are found in Massachusetts; the lignite on Martha's Vineyard; the bituminous coal along Connecticut river, particularly at South Hadley: and the anthracite at Worcester, and in small quantities, in the north part of Middleborough, in Bridgewater, and West Bridgewater, in Wrentham, and near the line of the State in Cumberland, Rhode Island. It is found also in small quantities at Turner's Falls, at Southampton, and at Enfield Falls, in the valley of the Connecticut. But do they occur in sufficient quantity and of such quality, as to render them of any statistical value?

The lignite exists in beds several feet thick, in the clay of the Vineyard: and although used as fuel in some parts of Europe, it burns so poorly that it will not be much used probably, until fuel shall become much more scarce.

Genuine bituminous coal, in sufficient quantity to be worked to advantage, has never been found, except in connection with a particular series of rocks, called the Coal Formation. Such a formation has long been supposed to exist in the valley of the Connecticut: extending across the whole of Massachusetts and Connecticut; and the strata have been bored in South Hadley, at least, in two instances, and once by a gentleman familiar with the real European coal formations. Several years ago, I myself delineated a coal formation, on a geological map of the Connecticut valley published in the American Journal of Science. But further examination has brought me, unwillingly, to the conclusion, that no such formation exists in that valley, and that the one which I then regarded as real coal measures, is in fact the new red sandstone, or its equivalent. In another part of this Report, I shall give my reasons for this conclusion. But I would remark, that I do not feel so much confidence in this opinion, that I would urge the entire abandonment of all efforts to find coal; for the facts stated in respect to anthracite, will justify the opinion, that even if the rocks under consideration, are new red sandstone, bituminous coal may exist in it, in sufficient quantities to be worth exploring; although in Europe it occurs in such rocks only in thin seams. Certainly the coal found at South Hadley was of a superior quality.

If, as I suppose, the rock under consideration be the new red sandstone, there is another fact that ought to be recollected, viz. that this rock, in other parts of the world, is associated with rock salt, salt springs, and gypsum. No trace of rock salt has been found in the Connecticut valley; and as yet only a small quantity of gypsum has been discovered.

Professor Silliman found a little of this mineral in the greenstone associated with the sandstone in Deerfield, and Mr. Davis, Principal of the academy in Westfield, found the same in thin scales, between the layers of the shale, connected with the sandstone, on the banks of Westfield river in West Springfield. I found a little of it also in the shale at South Hadley canal. These facts are sufficient encouragement for the research after gypsum. And when we recollect that on account of the softness of this mineral, it is liable to be deeply worn away at the surface, we should by no means despair of its existence in the valley of the Connecticut. I have compared a collection of specimens from the new red sandstone, that contains the gypsum of Nova Scotia, with the rocks of the Connecticut valley, and they can hardly be distinguished from each other.

As to anthracite coal, it seems to occupy a wider range among the rocks, than genuine bituminous coal. Generally, however, the former occurs lower down in the rocks, that is, in older rocks, than the latter. Sometimes it is found in what are called transition rocks; and sometimes in the primitive. In this country it is found in both these classes of rocks. We have in the United States, at least three extensive deposits of anthracite: the largest is in Pennsylvania; the next largest in Rhode Island; and the smallest in Worcester. I have examined them all, and have come to the conclusion, that all the rocks containing this coal, are at least as low down in the series as the transition class; and I am rather of the opinion, that they all lie below the Independent coal formation of Europe; I mean on the scale of rocks. I suspect that the Pennsylvania anthracite occurs in the higher beds of the graywacke, perhaps even in the millstone grit, and the Rhode Island anthracite, in the lower beds of graywacke. There is no geological connection between the Rhode Island and Worcester coal, as Dr. Meade and others have supposed. By inspecting the Map, the two localities will be seen to be separated by granite and gneiss, from twenty to thirty miles across. The Worcester coal occurs in an imperfect kind of mica slate. It is what Humboldt calls transition mica slate: for a few miles north, it passes into distinct argillaceous slate. Following the range south from Worcester, it becomes more decidedly micaceous, and probably there forms a bed in gneiss. Indeed, in Dudley, I saw the same rock surrounded by gneiss, and highly impregnated with anthracite.

The bed of anthracite in Worcester, is about seven feet thick, and has a moderate dip to the northeast. It has been explored only a few feet, and the operations are now suspended. To continue them advantageously, it will be necessary to go down the hill, and remove the soil so as to find the lateral outcrop of the bed, in order to avoid an accumulation of water. This work has been already commenced.

The Rhode Island beds of this coal were opened several years ago, before the value of it was justly appreciated by the community. The sales not being brisk, the works were abandoned, and have never since been resumed; so that on account of the rubbish, I was unable to ascertain the width of the beds. I have always understood, however, that there was abundance of coal. The beds are less favorably situated for working, than that at Worcester.*

The extensive, and rapidly increasing demand for the Pennsylvania coal, is a conclusive testimony to its first rate excellence. The experiments of Mr. Bull of Philadelphia, as well as those of Professor Silliman, recorded in the eleventh volume of the American Journal of Science, show that the best Rhode Island coal is not greatly inferior. The Worcester coal burns with more difficulty; but gentlemen who have fairly tried it, and on whose testimony I can depend, assure me, that it may be employed successfully, and comfortably for fuel. There can be no doubt, that its quality is inferior to the coal of Pennsylvania, and also to that of

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* A more particular account of the Rhode Island coal beds and their exploration, will be given in the third part of this Report.

Rhode Island.* But it may be very much inferior, and yet for many purposes, be exceedingly valuable. The fact is, anthracite has to struggle with prejudices wherever it is first introduced, arising chiefly from the comparative difficulty with which it is ignited; and it happens in regard to this substance, as with most things new and untried, that the community generally feel, as if their business was to find as many objections to it as possible; and the man who would bring any new substance into general use, needs no small share of patience, and perseverance. Dr. Meade states, that an experiment made several years ago at Smithfield, upon the burning of limestone, with the Rhode Island coal, and another upon the burning of brick, in the vicinity of Boston, were thought to be complete failures, because the heat was so intense, that the surface of the lime and of the bricks was vitrified; whereas the fact ought to have taught the experimenters, that a more careful regulation of the heat would ensure success. Indeed, I predict, that ere long, in nearly every case where a strong and steady heat is required, anthracite will be found superior to all other kinds of fuel; and that the anthracite of Rhode Island, and even that of Worcester, will be considered by posterity, if not by the present generation, as a treasure of great value. The Pennsylvania coal may indeed, for a great many years, command the market; but I apprehend, that the time will come, when the expense of its transportation to the Eastern States, and the increasing demand for it, will lead to the re-opening of the pits, that are now abandoned in New England.

In coming to the conclusion, that the anthracite of Worcester and even that of Rhode Island, are inferior to the Pennsylvania anthracite, geological considerations confirm the results of experiments. Baron Humboldt, who has probably seen more of the rocks of the globe than any man living, remarks, that 'anthracite is a more ancient formation than coal, and a more recent formation than graphite, or carburetted iron. *Carbon becomes more hydrogenated, in proportion as it approaches the secondary rocks.*' This last sentence, divested of its technical obscurity, means, if I understand it, that the newer the rock in which the carbon is found, the greater will be the quantity of hydrogen combined with it: and we know that an increase of hydrogen will render coal more combustible. Now if I am correct in the opinion, that the Worcester anthracite is contained in older rocks than that in Rhode Island, and the anthracite of Pennsylvania, in rocks still newer than those of Rhode Island, we might expect, that the newer would prove the best for fuel, and the older the poorest, because containing the least hydrogen. The quantity of carbon, however, in the Worcester coal, is believed to be nearly as great, as in that from Rhode Island and Pennsylvania; although no analysis has been made of the former. But carbon is less combustible than hydrogen. Yet I can hardly believe, that a coal, which contains probably not less than 90 per centum of carbon, should not be employed, in some way or other, as valuable fuel.

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* According to the experiments of Mr. Bull, a pound of the best Pennsylvania anthracite maintained ten degrees of heat in a room, 13 hours and 40 minutes; a pound of the Rhode Island coal maintained the same heat in the same room, 9 hours and 30 minutes; and a pound of the Worcester coal, kept up the same heat only 7 hours and 50 minutes. It is a curious fact that the specific gravity of the Worcester coal, is one third greater than that of the coal from the two former localities.

The formation which I have denominated graywacke, and which contains the anthracite in Rhode Island, extends northerly in interrupted patches, nearly across the whole of Massachusetts; as may be seen on the Map. The most southern patch, embraces nearly the whole of Bristol and part of Plymouth county; the second branches from the first at Wrentham, and extends to Dedham; the third includes several towns in the vicinity of Boston; and the fourth is in Rowley and Newbury in Essex county. I know of no reason, why one part of this formation should contain anthracite rather than another; and hence we may reasonably look for it in any part of the graywacke formation, exhibited on the Map. The transition mica slate containing the Worcester anthracite, occupies, as the Map will show, a large portion of the northeastern part of the State; and it would not be strange if other beds of that mineral should be found in it.

Graphite, Plumbago, or Black Lead.

This substance has the color of lead, leaves a trace like that metal upon paper, and bears the common name, *black lead;* but it contains no lead. It is composed of above 90 per centum of carbon, and the rest is iron and earthy matter. Hence it differs but little from some varieties of anthracite. It seems indeed to be the form in which carbon occurs in the oldest of the rocks. In Massachusetts it exists in gneiss, at the most important locality, which is in Sturbridge. It there occurs in a bed, varying in width from an inch to about two feet, and traceable along the surface, nearly one hundred rods. A number of years ago this bed was opened; and several tons of the graphite obtained. It was then abandoned; but within a few years the exploration has been recommenced, and already more than a hundred tons have been obtained. In some places the excavation is 60 or 70 feet deep. The quality of the graphite is excellent and would not suffer by comparison, with almost any in the world. To what extent it may be obtained, it is not possible at present to determine. The fact, that the bed descends, almost perpendicularly, into the earth, is rather unfavorable to the miner. Yet, as it is found upon elevated ground, the mine can be conveniently drained by lateral cuts or adits to a considerable depth; and probably the exploration may be profitably continued for a long time with little machinery.

Graphite is employed for pencils, crucibles, lubricating machinery, &c. It occurs at several other localities in Massachusetts, besides that in Sturbridge, but not in large quantities, except perhaps in Hinsdale. A good bed of it has been opened in New Hampshire.

A Substitute for Emery.

No real emery has yet been found in Massachusetts: but a rock composed of garnet, anthophyllite, or augite, occurs in North Brookfield, which is employed as a substitute for that mineral, and it is said to answer well. The powder of the garnet, although much inferior in hardness to real emery, is indeed sometimes called in commerce, *red emery*. The rock in Brookfield is abundant, and may prove valuable.

Tripoli or Rotten Stone.

At Paine's quarry of limestone in West Springfield, I found a mineral which subsequent examination has convinced me is genuine rotten stone: and so far as I have had opportunity of examining it, it appears to be of a superior quality. It occurs too in large quantities, and under circumstances similar to those in which it has been found in other parts of the world. I mean that it is associated with fetid limestone; being in fact that rock partially decomposed, and still emiting a strong fetid odor when struck. I hope that some mechanic, who has occasion to use this article, will thoroughly test that from Springfield, as I know of no other locality of any importance in the country. It does occur, however, at South Hadley falls, on the West Springfield shore. But the quantity is small, and it is not there associated with limestone, but appears to be an altered shale. (Nos. 217 to 221.)

Native Alum.

This valuable substance has recently been found in at least two places in Worcester county. It occurs on a variety of the gneiss rock of that county in delicate plumose or feather form masses along with copperas. Both these substances undoubtedly proceed from the decomposition of the rock and iron pyrites which it contains. Hence, as we know that artificial means will aid the production of copperas, we have reason to suppose that it will do the same in respect to the alum, as we know is done in other rocks. But no fair trial that I know of has yet been made I have received this alum from two places, viz. Leominster and Barre. A fuller account of it will be given in the third part of the Report.

Mineral Waters.

No mineral springs of much notoriety are found in the State, although chalybeate springs are very common, and are useful in cutaneous and some other complaints. Nearly all these springs rise in low ground containing bog ore. The Hopkinton spring is of this description, and is probably more resorted to than any other in the State. This contains, among other ingredients, carbonic acid and carbonate of lime and iron. The spring in Brookfield is similarly situated, and contains some magnesia and soda, as well as iron. It is a place of some resort. A mineral spring exists in Shutesbury, abounding in muriate of lime, and it is somewhat visited. Chalybeate springs exist in South Hadley, Deerfield, and indeed, in almost every town in the State. In Mendon I was shown a mineral well, in the waters of which, chemical tests indicate muriate of lime and carbonic acid in a free state. No use was made of the water, except as a substitute for yeast.

In Williamstown is a tepid spring very much resembling that in New Lebanon, N. Y. Bubbles of gas are constantly escaping, which, according to Prof. Dewey, are atmospheric air, and not simply nitrogen, which is common in such springs. The spring furnishes a convenient place for a bathing establishment; and though the saline ingredients are in small quantity, the water is useful in several cutaneous disorders. In Adams, Pittsfield, and in Great Barrington, are springs useful for the same complaints. In Hinsdale is a spring from which issues sulphuretted hydrogen; and from the decomposition of this gas, a deposit of sulphur is made upon the earth around.

Other non-metallic Minerals; either useful or ornamental.

It may be well in this place, perhaps, to notice briefly a few other mineral substances in the State, such as are employed in Europe for useful or ornamental purposes. In this country the demand for them is yet comparatively small, and we have few artists devoted to their preparation; so that no demand exists for these minerals, as is the case also with our porphyries.

In Hatfield, is an immense quantity of the sulphate of baryta of a superior quality. Within a few years, a patent has been taken out in England, for the use of this substance as a paint, to be employed in those situations where lead paint is liable to be acted upon by moisture, acids and other chemical agents. In such cases this barytic paint is excellent. I have been in the habit, for several years, of having various articles in the laboratory, such as the pneumatic cistern, gazometer, &c., covered with it; and it answers a good purpose, although I have prepared it, not according to the patent, but simply by grinding it in a plaster mill and mixing it with oil. The greatest defect in this paint, seems to be, that it has less body than lead, although I doubt not that a remedy may be found for this difficulty. When the baryta is thoroughly pulverized, and mixed with boiled linseed oil and lampblack, it is superior to any thing I have ever seen, for labelling glass bottles, &c., in a laboratory, and indeed for any situation exposed to active chemical agents.

The new alkali, lithia, is found chiefly in two minerals, called petalite and spodumene, which, in Europe, are very rare. But in Massachusetts they occur in large quantities; particularly the latter. The former is found in Bolton, and the latter in Goshen, Chesterfield, Norwich and Sterling. The lithia can now be obtained, by a chemical process, from the minerals of these localities, in any quantity; and should it prove to be a useful substance, as every alkali is likely to be, these minerals may become an object of importance.

Among the minerals in the State, that may be employed by the lapidaries, for ornamental purposes, may be mentioned chalcedony. Almost all its varieties occur in the greenstone ranges, in the valley of the Connecticut, and some of the agates which it forms are quite large, and need only polishing to be elegant. It occurs also in various other parts of the State, and in masses of considerable size, and it may be worthy the attention of the lapidary.

Agates, both banded and brecciated, are found in the State, made up of quartz, hornstone, chalcedony, &c. of various colors. The largest and most perfect specimen of quartzose agate breccia, which I have found, was shown me at Rochester centre; and I was told it was broken from a much larger mass, in the same town. (No. 1103.)

In Saugus near the centre, is a fine locality of red jasper. It is not unfrequently striped, and if needed for ornaments, would admit a fine polish; as Nos. 388, 389, and 390, show. The bed or vein has not been explored at all, except that a few fragments have been broken off by the passing mineralogist.

We have beryls, somewhat numerous, and sometimes very large; but probably they are not delicate enough, and are too much divided by seams, to be employed for elegant ornaments.

A garnet or cinnamon stone was found by Professor Webster in

Carlisle, which, in its natural state, is a splendid gem. Good specimens, however, cannot now be obtained, without farther exploration of the soil, or the rock.

The quartz crystals, that occur at several localities, are very perfect, and might be used for watch seals, ring stones, spectacles, &c.; those, for instance, found at Pelham, Southampton and Williamsburg. The smoky quartz occurs at a few localities, and is fine for ornaments. At Southampton, Pelham and Middlefield, is found the yellow quartz, which in some instances, can scarcely be distinguished from genuine topaz. The rose red quartz occurs at several places, as at Chelmsford, Chesterfield, Chester, Williamsburg and Blanford; and sometimes, I am inclined to believe, of a good quality to be wrought into ornamental articles; particularly, at one or two localities recently discovered. The amethyst, which occurs in greenstone, near Connecticut river, is of a delicate color, and, if it can be obtained in sufficient quantity, may be employed in the ornamental arts.

Some of the adularia that is common in the gneiss of Brimfield, Southbridge, &c., I presume, would answer well for watch seals, rings and trinkets; particularly, a greenish variety, occuring near the centre of the latter place. I have seen an elegant watch seal, cut from the adularia of this locality. A polished specimen will be found in the collection. (No. 1086.)

It ought not to be forgotten, that amber has been found in Martha's Vineyard, at Gay Head, and on Nantucket. At the latter place one or two masses were found, weighing a pound or more. The tertiary formation of these islands is precisely the place where we might expect to find this mineral, especially in connection with the lignite.

METALS AND THEIR ORES.

It remains only, in giving the economical geology of Massachusetts, to describe the metals and metallic ores which have been found in the State, and are applicable to useful purposes. I shall begin with the metal most abundant and most useful: viz.

Iron.

The bog iron ore is most common, but I shall give an account of the different species in regular order.

Mine of Arsenical Iron and Carbonate of Iron, in Worcester.

In the town of Worcester, in mica slate, is a bed of these ores, which was explored to some depth, a number of years ago, in search of the precious metals. A little galena or lead ore is found also, in the same mine. As the excavations are now nearly filled up, it is impossible to judge of the extent of this bed.

Arsenical iron is seldom explored for the purpose of getting malleable iron from it; although it is sometimes employed for the arsenic it contains, and for the preparation of sulphuret of arsenic. The carbonate of iron is an excellent ore; and has received the name of steel ore, because it may be readily converted into steel.

Mine of Carbonate of Iron and Zinc, in Sterling.

This is a bed, in mica slate, just like that at Worcester; and was extensively explored forty or fifty years ago, for the same purpose which led to the opening of that bed, viz. the discovery of gold and silver. The carbonate is the most abundant ore, and lies scattered about the excavation, in considerable quantities; although the sulphuret is common, which is sometimes arsenical. A reddish, foliated sulphuret of zinc also occurs here, in considerble quantity, and some sulphuret of lead. Whether this mine will be found worth exploring, it is difficult in its present state, to determine. If it afford the carbonate of iron in large quantities; it will certainly repay the effort. It lies about a mile and a half southeast of the centre of the town.

Chromate of Iron.

It ought to be recollected, that a small rounded mass of this ore, so valuable in the preparation of the paint called *chrome yellow*, was found, a few years since, in Cummington, by Dr. Porter.

Postscript.—While the second edition of the first part of this Report was passing through the press, I discovered the chromate of iron in serpentine in Blanford. The serpentine itself has been brought to light since the printing of the first edition, and occurs in the northwest part of that town. The chromate is disseminated through the serpentine, and exists in it also in considerable masses, or in veins. I picked up specimens weighing from four to five pounds; but made no exploration to ascertain the quantity in the rock. The mineralogical character of this mineral will be reserved for the third part of the Report. It it hoped that this notice will call the attention of practical men to this locality.

Phosphate of Iron..

The earthy variety of this ore has been found, in considerable quantity, at the mineral spring in Hopkinton. It forms a bed, one or two feet below the surface, and has been employed as a pigment. It is said to exist also near Plymouth.

Sulphuret of Iron, or Iron Pyrites.

This is the yellow ore so frequently mistaken for gold. It occurs more or less in almost every rock; but is of no use, unless it exists in large quantities, and is of that variety which easily decomposes. In such a case, it may be converted into the sulphate of iron; that is, into copperas. The ore is broken up, and exposed to the action of air and moisture, when the change takes place, and the lixivium is evaporated to obtain the copperas. In Massachusetts, one can hardly avoid meeting with iron pyrites; and in the western part of Worcester county, the traveller cannot but notice, that nearly all the rocks are coated over with iron rust. This is the result of the decomposition I have spoken of. In Hubbardston, the sulphate is so abundant, that a manufactory of copperas has been established, and I believe success has thus far attended the enterprise. I should presume that copperas might be manufactured in several other towns south of Hubbardston; as in North Brookfield and Southbridge, although the rocks do not appear as highly impregnated with pyrites in any place as in Hubbardston.

The decomposition of pyrites, in large quantities, often produces a considerable degree of heat; and sometimes pieces of rocks are driven off with explosion. This is one of the sources of those numerous stories which one hears in the country, concerning noises heard, and lights with smoke, seen in the mountains. Such occurrences excite the belief of the existence of valuable mines in the vicinity; but they evince the existence of nothing more than iron pyrites.

Magnetic oxide of Iron.

This is a valuable ore, affording from 50 to 90 per cent of iron. It exists in several places in Massachusetts, and on the borders of the State.

Hawley Iron Mine.

The principal ore here is the magnetic oxide, which is very good, and the bed is favorably situated for exploration. The ore does not seem to be abundant, the bed being rarely more than one or two feet wide. It has been wrought to some extent; but the operations are at present suspended. It belongs to Hon. Samuel C. Allen. Micaceous oxide of iron occurs at the same bed.

The same bed of ore makes its appearance a mile or two south of the excavation: and also, as I have been told, two or three miles north, in Charlemont.

In Bernardston.

As already remarked in the postcript to limestone, this forms a bed several feet thick in limestone, dipping at a moderate angle to the southeast. When the ore was formerly worked, some complaint was made, as if it did not produce the best of iron. But probably the trials then made were very imperfect. The ore is doubtless very abundant, and I should think well worthy the attention of the iron manufacturer.

In Somerset, Vt.

This bed is similarly situated to that in Hawley, and in the same range of talcose slate, although twenty miles north of the north line of Massachusetts. The ore, yielding 78 per cent of iron, is of the first quality; and this spot is peculiarly interesting on another account, to which I shall refer in the sequel.

In Winchester, N. H.

This bed is only two or three miles north of the line of Massachusetts, and the ore is said to be abundant, though for some reason the working of it has ceased. The ore very much resembles that from Franconia in New Hampshire.

In Cumberland, R. I.

Dr. Robinson says that he has obtained magnetic oxide of iron, from 'most of the thirteen mine holes' which he visited in that town. But the principal bed of ore lies about two miles northeast of the meetinghouse, and constitutes a large hill. It is obtained with great facility by blasting. It contains, however, several foreign minerals, so that as it is now worked, it yields only about 30 per cent of iron. This is probably far less than it contains; for it has a high specific gravity. The ore is smelted principally in Massachusetts. It is owned by General Leach of Easton, and will furnish an inexhaustible supply.

Magnetic oxide of iron is found at other places in Massachusetts; as at Woburn, in a vein of greenstone, associated with sulphuret of copper: but at none of the localities, in quantity sufficient to make it an object for the miner.

Micaceous Oxide of Iron.

This ore, which is found abundantly at Hawley with the magnetic oxide, furnishes perhaps the most elegant specimens in the world; and I know not why it should not produce good iron. Indeed, I believe it has been smelted within a few years, along with the magnetic oxide.

Vein of Micaceous Oxide in Montague.

Near the mouth of Miller's river is a hill of considerable extent, which appears to be traversed by numerous veins of this ore. The largest which comes in sight, is in the southeast part of the hill, at the top of a ledge of mica slate and granite, and is several feet in width. It is favorably situated for exploration, and unless the ore is injured by an occasional mixture of sulphuret of iron, I do not see why it might not be profitably wrought. Wood is very abundant in the vicinity, and it is not far from Connecticut river. Good micaceous oxide of iron, yields about 70 per cent of excellent iron.

According to Professor Webster, thin veins of micaceous iron ore exist in the porphyry of Malden, which were formerly wrought to some extent. It occurs also in graywacke, at Brighton, and in greenstone at Charlestown, according to the Messrs. Danas.

Hydrate of Iron.

Several varieties of ore heretofore regarded as distinct species have lately been brought together under this name. It embraces the brown and red oxides, and the argillaceous oxides, and of course comprehends the greater part of the iron ores in the State. I shall describe the different varieties under the names that have been most commonly applied to them.

Beds of Brown Oxide of Iron.

This ore is of an excellent quality, and it occurs in the loose soil above the rocks so as to be easily obtained. Hence it is used to a greater extent, perhaps, in our country, than any other variety. A very extensive series of beds of this ore, accompanies the limestone that is so abundant along the western margin of Connecticut, Massachusetts, and Vermont; although, as the beds lie upon the clay that is deposited above all the solid rocks, they have no necessary connection with the limestone.

Beds in Lenox.

These have been explored to some extent in the village, and a mile or two farther west. The ore is good, I believe, but at present it is not used.

Beds in Richmond.

These appear to be numerous and extensive. They are wrought to some extent.

Bed in West Stockbridge.

This furnishes good ore, and is explored more extensively than any other I saw in the county. The farmer who owns it receives thirty seven cents and a half per ton, of those who dig it.

In Salisbury, Ct.

The beds here are very large, and have been extensively explored. The Salisbury iron is known far and wide.

In Bennington, Vt.

Here also the same ore is dug to some extent; and these beds seem to deserve a notice, because they lie, like those in Salisbury, upon the borders of Massachusetts.

In all the beds of brown oxide of iron mentioned above, we find the brown hæmatite in all its forms; the compact, the fibrous, and the ochrey brown oxide, or yellow ochre. Manganese also is found in them all, and at Bennington in large quantities. It is, for the most part, of a superior quality.

The red oxide of iron is found, in comparatively small quantities, at the localities above mentioned. It exists, also, in other places in the State, and especially at Conway, with manganese; although it is not as yet, found in large quantities. Argillaceous oxide of iron is likewise found at most of the hæmatite beds above described.

In Cranston, R. I.

From this place General Leach procures, as he told me, very excellent brown oxide of iron, for the supply of some of his furnaces in Massachusetts, and he represents the bed as inexhaustible.

Argillaceous Oxide of Iron.

This is the most common species of iron ore in Massachusetts. There are several varieties found here. On Nantucket and Martha's Vineyard, particularly at Gay Head, we find the nodular, columnar, mamillary, pisiform, and ochrey varieties. On the Vineyard these varieties are abundant enough to be an object for the manufacturer; and during the last war, I was told, they were employed in the furnaces on the continent. In a pond, in Sharon, has been found the lenticular variey of this ore.

Bog Ore.

This variety of the argillaceous oxide, is far more abundant than any other, and has been used extensively in the manufacture of cast iron; for which it is chiefly adapted. In the following towns it is found in large quantities: viz. Groton, North, West, and South Brookfield, Carver, Hopkinton, Hardwick, New Braintree, Oakham, Berlin, Sturbridge, Southbridge, Freetown, Dartmouth, Rochester, Troy, Easton, and Sharon; and in the following, it exists greater or less quantities; in Middleborough, Malden, Seekonk, Sheffield, Templeton, Warwick, Williamstown, Greenfield, Northampton, Springfield, Williamsburg, Dalton, Holland, Wales, Norton, Mansfield, Bridgewater, Stoughton, Spencer, Gloucester, and on Martha's Vineyard: indeed, I can hardly doubt that more or less of this ore may be found in nearly every town in the State. I found it so common that at length I ceased to enquire for it, and the localities are so numerous that I have not attempted to exhibit them all upon the Map.

It ought to be recollected, that the process by which bog ore is deposited, is in many places now going on, particularly at the bottom of ponds. The interval between one dredging and another, was so variously stated to me, that I suspect it differs greatly in different places. I presume, however, that it ought never to be less than twenty years. But the fact, that there will be a renewal of the deposit after a certain time is interesting: because it shows that this mineral can never be entirely exhausted.

Gen. Shepard Leach,* of Easton, is the most extensively engaged in the iron manufactory of any man in the Commonwealth. He owns one blast and three air furnaces in Easton; one blast furnace in Foxborough, and another in Walpole: and two blast furnaces and four air furnaces, in Chelmsford. In these he employs not far from five hundred men. He generally mixes the different sorts of ore, or at least, two or three of them together for smelting. Extensive iron works are also carried on in Wareham. Several furnaces exist in Berkshire, and a few in Worcester county.

The preceding view of our deposits of iron, demonstrates that we abound in this useful metal, and that the demand for centuries to come, cannot exhaust it.

Ochres, &c., used as paints.

There are two kinds of ochre, the red and the yellow, which are merely pulverulent varieties of the red and brown oxides of iron. The yellow ochre is abundant with our hæmatite and argillaceous ores, and is frequently employed as a pigment. According to Mr. C. T. Jackson, red ochre occurs in Boylston in a bed four or five inches thick, mixed with clay. It has already been mentioned, that the earthy phosphate of iron in Hopkinton, is employed as a blue paint. Prof. Dewey mentions that a yellow earth is found in Williamstown, from which great quantities of yellow ochre are obtained by washing. Dr. J. Porter states, that yellow earth occurs in Monroe, which, when purified, affords a 'pale red paint.' The process of preparing it he says is now suspended for want of a demand.

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* Now deceased, (1834.)

Lead.

Several ores of this metal are enumerated by mineralogists, as occurring in Massachusetts; but none is found in sufficient quantity to render it of any statistical interest, except the sulphuret, commonly called *galena;* and all the important veins of this species are confined to the vicinity of Connecticut river. No fewer than thirteen of these occur in that region of sufficient importance to deserve notice. All these are in mica slate or granite; or they pass from the one rock into the other.

In Southampton.

The vein in the northern part of this town has attracted more attention than any other in the region, and has been several times described. It is six or eight feet wide where it has been explored, and traverses granite and mica slate, the matrix or gangue containing the ore, being a mixture of quartz and sulphate of baryta. It has been opened forty or fifty feet deep, in several places, and masses of ore were dug out from half an inch to a foot in diameter. As the vein descends almost perpendicularly into the rock, water soon accumulated in such quantities, as induced the proprietors to attempt reaching the vein by a horizontal drift or adit, from the bottom of the hill on the east side. This was no small undertaking, as the opening must be carried nearly a quarter of a mile into the solid rock. It was persevered in, however, at a great expense, for a distance of nearly nine hundred feet, when one of the principal miners having died, and the price of lead having fallen two or three hundred per cent, all operations were suspended, and I believe the proprietors wish to dispose of the mine. Had they continued this drift a few feet farther, there is every probability that the principal vein would have been struck, from one hundred and fifty to two hundred feet below the surface. Perhaps, however, the work cannot be successfully and profitably resumed, until the market shall cease to be glutted with lead from Missouri; but there can be little doubt, that immense quantities of ore may be obtained at this spot, it may then probably be explored with advantage. I do not doubt, however, that those who first examined this mine were mistaken in the opinion that this vein extends from Montgomery to Hatfield, a distance of twenty miles. Lead may indeed be found at intervals along a line connecting those places. But I have every reason to suppose, that it proceeds from several distinct and independent veins.

The principal ore above described is the sulphuret; but there have been found here also, the carbonate, sulphate, molybdate, muriate and phosphate of lead, along with the sulphuret of zinc, pyritous copper, and fluor spar. Mineralogists will greatly regret, that mining operations have been suspended here, because they were anticipating the developement of rich specimens of these and other minerals.

Another vein of galena exists in the south part of Southampton, near the line of Montgomery. It appears for several rods on the surface, but is only a foot or two in breadth. A few years ago, efforts were made to open this vein by a horizontal adit, but the proprietors have become discouraged and abandoned the undertaking.

In Northampton.

This vein is only a short distance north of the principal vein in Southampton, above described. The gangue is radiated quartz, and the walls are mica slate. Yellow blende or sulphuret of zinc abounds here; and the vein was formerly explored to a considerable depth. It is several feet wide.

In Westhampton.

This vein has been usually described as existing in Williamsburg and extending into Northampton. But so far as it exhibits itself at the surface, it lies wholly in Westhampton—in quite the northeast part of the town, only a few rods from the Northampton line, and but half a mile from that of Williamsburg. The gangue is quartz, and the vein is several feet wide, and may be traced 30 or 40 rods. But the quantity of galena is small at the surface.

In Williamsburg.

A vein of galena lies in the northeastern part of this town, and probably extends into Whately. It is two or three feet wide, and the gangue, as in nearly every other vein of lead in this region, is quartz. Manganese is found in the same gangue.

A second vein of quartz with galena occurs in this town, a mile or two northeast of the one last mentioned. The quartz, however, appears only in loose masses on the surface, but to such an extent, as can be explained only on the supposition, that a vein exists in the rock beneath the soil. Pyritous copper is found in connection with the galena at this place.

In Goshen.

According to the statements of Mr. Alanson Nash, who has given a map and description of the lead veins and mines of Hampshire county, in the twelfth volume of the American Journal of Science, the same indications of a galena vein appears a little west of the centre of Goshen, as those mentioned in respect to the third vein in Williamsburg just noticed, viz. the occurrence of masses of quartz containing galena. The rock in the region is mica slate and granite.

In Whately.

In this town are three distinct veins containing lead. One is about half a mile east of the first vein described in Williamsburgh. It extends a short distance into Williamsburg, and more than a mile into Whately. In its whole course, but particularly at its southern part, it contains oxide of manganese along with galena.

A second vein, three or four feet wide, exists in a high ridge of granite towards the southwest part of the town. It may be traced along this ridge about three quarters of a mile.

The third vein is in the northwest part of the town, extending some distance into Conway. Galena, in quartz, is the only ore that appears on the surface. The width of the vein is six or seven feet, and it traverses both granite and mica slate. It runs along the western margin of a high hill, so that if it should ever be explored, a lateral drift could be easily made.

In Hatfield.

About two miles west of the village in this town, we find a vein of sulphate of baryta, from one to four feet wide at the surface, running in a northwesterly direction and containing galena. A shaft has been sunk in two places, from fifteen to twenty feet, deep; and the vein was found rapidly to widen in descending. The immense quantity of baryta found here, gives the locality a peculiar interest to the mineralogist.

In Leverett.

Although this town lies on the eastern side of Connecticut river, yet the granite and mica slate, occurring there, exactly resemble the same rocks found on the west side of the river; and there can be no doubt that both belong to the same general formation. Two veins, the ore being chiefly galena, are found of precisely the same character as those on the opposite side of the river. That in the southeast part of the town is in granite, not more than a foot or two wide at the surface, and the gangue is sulphate of baryta. The other is a mile and a half to the north of the first; the gangue is quartz, and there is almost an equal quantity of galena and pyritous copper; blende also occurs in small quantities. This vein is several feet wide, and runs through granite and mica slate. Both this and the one first mentioned, have been explored to the depth of a few feet.

It is impossible to form any confident opinion as to the probable quantity of lead, which is contained in the several veins which have been described, except, perhaps, in regard to that in Southampton, which has been explored to a considerable extent. In many instances appearances at the surface are quite favorable; but whether the veins become wider, like that in Hatfield, or narrower as they descend, can be determined only by actual exploration. Of one thing, however, I think we may be assured, from the facts that have been stated; viz. that the central parts of Hampshire county contain extensive deposits of lead, which may be of great value to posterity, if not to the present generation. Probably many more veins will hereafter be discovered, since little examination has been made with a view to bring them to light.

Copper.

This valuable metal occurs in numerous places near the junction of the greenstone and sandstone, in the valley of the Connecticut, between New Haven and Vermont. Several veins of copper ore are found in Connecticut; and the only one in that state, that has been explored to any considerable extent, lies on the borders of Massachusetts, viz. in Granby. It has long been known under the name of Simsbury mines, although it is within the limits of Granby. Many years ago, before the war of the revolution, I believe, this vein was explored to a considerable extent. Afterwards the government of Connecticut made use of the abandoned shafts and galleries for a State Prison. Since the removal of this prison to Weathersfield, the exploration has been resumed, by a new company, and, as I am informed by the agent, with success. The principal part of the ore is the red oxide, associated, however, with green carbonate.

In Greenfield.

In the northeastern part of this town, on the banks of Connecticut river, are two veins of copper ore about a mile apart; the most northern one being about one hundred rods below the mouth of a small stream, called Fall River, and the same distance in a direct line from the cataract in Connecticut river, sometimes called Miller's Falls; but lately, and more appropriately, Turner's Falls. These veins are several feet in width, and they pass into a hill of greenstone on one hand, and under the river on the other into sandstone. The gangue is sulphate of baryta and toadstone, and the ores are the green carbonate and pyritous copper. Actual exploration alone can determine whether these veins might be profitably worked.

On the most southern of the small islands, in the middle of Turner's Falls, has been found a vein of pyritous copper, of a rich quality, and in considerable quantity. Indeed, several varieties of the sandstone rocks in the vicinity, appear to be considerably impregnated with copper.

Pyritous copper is associated with iron, in a vein, in greenstone, at Woburn; but not, probably, in a sufficient quantity, to be worth mining. At several places in Cumberland, R. I., where excavations were formerly made, are found gray oxide of copper and pyritous copper with the green and blue carbonates.

Zinc.

The sulphuret of this mineral occurs, as has already been noticed, in several of the lead veins of Hampshire county, and in some of them in sufficient quantity, no doubt, to be wrought with advantage, should these veins be ever opened. Those in South ampton, Hatfield, and Leverett, abound most in this ore. It is useful in the manufacture of brass and white vitriol.

Manganese.

In a metallic state this mineral is of no use; and indeed, it is reduced to that state with great difficulty. But in the state of oxide, it is extensively employed, both to remove color from glass and to impart colors; also in painting porcelain and glazing pottery, and still more extensively within a few years, in the manufacture of the chloride of lime, now so generally used in bleaching and for disinfection.

At least three ores of manganese abound in the western part of Massachusetts and on the borders of New Hampshire. It has been already remarked, that more or less of the gray oxide exists in the iron beds of Berkshire, and Bennington, Vt. In the vicinity of Connecticut river, however, or rather on the eastern slope of Hoosic mountain, distinct veins and beds of manganese are found.

In Plainfield.

Beds of the oxide of manganese occur in two places in this town, one a mile west of the centre, and the other near the southwest corner of the town; and both in talcose slate. Two ores are associated at both these places, viz. the common gray or black oxide and the silicious oxide; the former investing the latter as a black crust, and most probably proceeding from its decomposition; while the latter, when newly broken, is of a delicate rose red. I suspect the silicious oxide predominates at these places; and from these beds, probably came by diluvial action, those numerous rounded masses of silicious oxide in the vicinity of Cummington meetinghouse; although a deep valley intervenes, and the distance is three or four miles.

An attempt was made, some years ago, to explore one of these beds, under the impression that the ore was iron. But how extensive either of them is, it is difficult to determine, as each seems to consist of a number of small beds, or rather the ore is interlaminated with the slate. The occurrence of so much silicious oxide at these localities, is very interesting to the mineralogist, because this ore is so rare in Europe.

In Conway.

A distinct vein of the black oxide of manganese several feet wide occurs in the southeast part of this town, the gangue being quartz. It has not been explored at all; nor is the manganese ore very abundant at the surface. I do not doubt, however, that this ore may be found here in large quantities.

In Hinsdale, N. H.

An extensive bed or vein of the black oxide, and ferro-silicate of manganese has been found in this town. It appears near the top of a hill and the adjacent rocks are not visible.

In Winchester, N. H.

Between one and two miles east of the centre village in this town, may be seen large quantities of the black oxide and ferro-silicate of this metal of the same character as in Hinsdale. These localities have, as yet, attracted no attention except from a few mineralogists. My information and specimens were furnished me by Mr. John L. Alexander of Winchester.

Tin.

I am able to say with perfect confidence that this interesting metal exists in Massachusetts: but can add little more. I found only a single crystal of its oxide, weighing 50 grains. But this I dug myself from a block of granite in the northwest part of Goshen, and on reducing it to metallic tin, it corresponds exactly in every respect with that metal from England. I have never been able to find any more specimens, but it ought to be borne in mind that in England, according to a geological writer of that country, 'it is generally in the vicinity of a vein of tin ore, that disseminated grains of tinstone are found in the rock.'

Mohs, in his Mineralogy, mentions that some small crystals of tin were found in specimens sent to Europe from Chesterfield, Mass.

Silver.

The only place in the State where this metal has been discovered, is at the Southampton lead mine; it there exists in a small proportion—only 12 1-2 ounces to the ton,—in the galena. This is a little greater than the average proportion in the English lead ores; but it is hardly worth the labor of separating it. It is not improbable that when several other ores in the State, such as arsenical iron, sulphuret of iron and of zinc, shall be accurately analyzed, they will be found, as in other countries, to contain a larger proportion of silver. I would, however, rather discourage than encourage, farther researches for this metal; for as I shall soon have occasion to state more fully, greater expense has been incurred and more weakness and folly exhibited in such researches, than the community is generally aware of.

Gold.

It may perhaps excite a smile, to see gold occupying a place in a description of the minerals of Massachusetts. It has not indeed been found in this State; *but I am able in this place, to announce the existence of a deposit of this metal, in the southern part of Vermont;* and I feel no small degree of confidence, that it will be found in Massachusetts. A statement of the grounds of this belief, may save me from the charge of extravagant expectations.

I have already described an iron mine, as occurring in Somerset, Vermont. It is owned by S. V. S. Wilder, Esq. of Brooklyn, New York, who has erected a bloomery forge near the spot. Sometime ago, one of the workmen engaged in these iron works, saw in the American Journal of Science, a suggestion of Professor Eaton of Troy, that since the gold of the Southern states, and of Mexico, is in talcose slate, we might expect to find it in the same rock in New England: especially about the head branches of Deerfield river. He commenced an examination in a brook near the mine, and was soon rewarded by the discovery of a spherical mass of gold, of the value of more than a dollar; afterwards he found other small pieces. At the request of Mr. Wilder, I visited this spot a few weeks ago, and found that an individual conversant with the gold mines in the Southern states, and acquainted with the process of washing the metal from the soil, had just been examing the region now spoken of. The result was a conviction, that over several hundred acres at least, gold was common in the soil. In a bushel of dirt collected in various places, he found about three penny weights of very pure gold. Mr. Wilder proceeded himself to exhibit to me an occular demonstration of the existence of gold in the soil, by washing for it. From about six quarts of dirt, taken a foot below the surface, we obtained (although not very skilful in the manipulations of this sort) twenty or thirty small pieces, weighing about seven grains. Indeed, by the aid of my knife, I picked two or three pieces from the dirt.

The iron ore is in beds in distinct talcose slate; and a considerable part of the ore is the hydrous, and contained in a porous quartz. In this quartz, were found several spherical pieces of gold, scarcely larger than a pigeon shot. It exists, also as in the Southern states, in finer particles, in the yellowish iron ore. And specimens of the quartz and iron at this place, cannot be distinguished from what is called gold ore, at the gold mines in Virginia, and North Carolina. Indeed, a suite of specimens from the Somerset iron mine, could not be distinguished, except by labels, from a similar suite from the south.

In every case in which gold has been found at this place, in the soil, it was accompanied by more or less of iron sand, and some distance north of the mine, neither could be found; but how far to the South and East it occurs, has not been ascertained. I am inclined however to believe, that the gold at this locality, will be found to be always associated with the iron.

We were told at Somerset, that several years ago, a mass of gold was found in the bed of Deerfield river, three or four miles to the south of the mine, which was sold for sixty eight dollars, and we had no reason to doubt the statement. Certain it is, that a few years since a piece was discovered by Gen. Field, weighing eight and a half ounces, in New Fane, a town twelve or fifteen miles east of Somerset.

Upon the whole, it appears to me that the facts above stated justify the conclusion, that there exists a gold region in the lower part of Vermont, of considerable extent and richness.* It may be found to be very extensive, and probably is not confined exclusively to the talcose slate formation; for New Fane, I believe. contains but little of this rock. The region west of Somerset is little known; the iron mine there, lies at the foot of the Green Mountains, and it is chiefly a mountain wilderness for sixteen or seventeen miles west of this spot.

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* Some paragraphs have recently been going the rounds of the newspapers, (Jan. 1834,) whose object is to throw doubt over this whole account of the Vermont gold. The story which the writer gives about the New Fane gold having been

The talcose slate formation, containing the iron and gold in Somerset, extends southerly, nearly across the State of Massachusetts; passing through the towns of Rowe, Charlemont, the settlement called Zoar, Florida, Savoy, Hawley, Plainfield, Cummington, Worthington, Middlefield, &c. Indeed, I know of no place, where the formation is so perfectly developed in its characters, as in Hawley and Plainfield. There is then, surely, as much ground for presuming that gold will be found in Massachusetts, as there was for predicting its discovery in Vermont. If an iron mine and porous quartz, with hydrous iron, be necessary, we have these in Hawley, in the talcose slate. And it ought to be recollected, that the Vermont gold was found at the source of Deerfield river, and that this stream runs directly south into Massachusetts; and it would be rather strange, if so violent a torrent, did not carry some of the diluvium, containing gold, at least as far the limits of this State. The places where I suppose gold might be found in Massachusetts, are in the vicinity of Hawley iron mine, or the Plainfield beds of manganese, or along the banks of Deerfield river, in Monroe, Florida, Zoar, and Charlemont: nor should the region around the limestone and iron ore, in Bernardston, be forgotten, in an examination for this metal, although the rock there is not talcose slate. Talcose slate occurs also in many other places in the State; particularly in Berkshire county, on the Taconic range of mountains, and other eminences; and here also are porous quartz and hydrous iron. I have found time to make only a slight examination for gold, in one or two of the places above mentioned. The surest method of determining the point, would be to obtain some one, who is conversant with the gold regions at the south,

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buried by counterfeiters, I heard told some years ago; but it is extremely improbable; and General Field, who found it, states that it contained crystals of quartz, proving it to be native gold at least. As to the Somerset gold, the writer cannot be more sceptical about its existence than I was, when first I visited the spot: but when I was actually able to find fragments almost any where over a wide extent of surface, by digging where the soil did not appear to have been disturbed since the time of the last deluge, I could doubt no longer; nor could I believe, as this writer insinuates, that some speculating gold digger had been *sowing* southern gold there so extensively. That gold exists at Somerset cannot it seems to me be reasonably doubted any longer; but whether in sufficient quantity to be profitably explored, I do not know. And I think the proprietors of the soil act very wisely in not proceeding to incur much expense in digging and washing for gold, until they are satisfied on this point.

and with the mode of washing it, to examine the places which I have mentioned. It may indeed be doubtful, whether the discovery of gold would be a public benefit; since, as your Excellency has well observed, it might lead to 'the greedy pursuit of this uncertain gain, and to the sure sacrifice of habits of industry and economy, and virtuous self-denial, which the ordinary pursuits and requirements of business induce. We may doubt even, whether the grass-covered hills of our own New England, are not a better source of wealth, and contentment, than the precious metals which the earth embosoms.' But, however political economy might decide these questions, I suppose there are few individuals who would willingly shut their eyes upon gold mines; and therefore I have made these suggestions on the subject, to prevent expenditure upon useless and ill-planned projects, in search of this precious metal.

Idle search after Gold and Silver.

Were the history of the wild and ill-directed efforts that have been made, even in Massachusetts, in search of the precious metals, to be written, it would furnish many striking illustrations of the importance of your Excellency's suggestions. Permit me here to state a few facts on the subject.

The large quantities of the precious metals carried to Europe from South America, soon after its discovery, naturally produced some expectation of finding similar treasures here. But I cannot learn that our forefathers expended large sums in making excavations, where there was no reasonable prospect of finding any thing valuable. It was reserved for their descendants to exhibit a credulity and superstitious ignorance on the subject, that are both lamentable and ridiculous.

Perhaps, at the present day, a belief in the mysterious virtues of the mineral rod, is the most common of these delusions. Probably many of our intelligent citizens can hardly credit the statement, that there are men in various parts of the State, who profess not a little skill in this enchantment, and are not unfrequently sent for, one or two days' journey, to decide whether there be ore or springs of water in a particular place. In general, but not always, these professors of divination belong to the most ignorant classes in society; for not long since, a venerable and respectable man of good education, sincerely thought it his duty, occasionally to peregrinate with his divining rod, because *it would work in his hands;* and not a few intelligent men have a secret belief that the branches of a witch hazle are attracted downward towards mineral substances, when in the hands of a certain individual.

The following train of circumstances often takes place. A man, ignorant of mineralogy, finds upon his farm, a specimen of iron pyrites, or yellow mica, or galena, which he mistakes for gold or silver. Even if he shows it to a mineralogist, and is told that he is mistaken, he suspects that his informant is deceiving him, in the hope of getting possession of the prize himself. He resolves to begin an excavation. And he sees enough, in the shining particles of mica and feldspar that are thrown out, to buoy up his hopes, until his purse is well nigh drained.

It was probably in some such way, that the excavations were made in Worcester and Sterling, at the mines of arsenical iron and carbonate of iron; although, in these cases, there would be sufficient ground for obtaining some of these ores, since they do sometimes contain silver. But I cannot conceive why such extensive excavations were made, when a chemist might have easily settled the question as to their nature, by analyzing 100 grains of the ore, unless it was on the erroneous supposition, which I find to be common, that metallic veins generally become much richer and larger, and even change their contents, as they descend into the earth.

The decomposition of iron pyrites, producing heat and sometimes explosion, is supposed by some to be a strong indication of mineral riches in the earth beneath. The man of the witch hazel rod is called, and if he confirms the suspicion, as he usually will, the excavation is commenced; nor is it suspended until a heavy draft has been made upon the man's pecuniary resources. An extensive excavaion was made, many years ago, I am told, in Hubbardston; and from the character of the rock there, I suspect that pyrites gave the first impulse to the undertaking. In Pepperell, an individual has been engaged for several years, in pushing a drift into the rocks, which he has penetrated eight or ten rods; although individuals who have visited the spot, (I have not,) can discover nothing but iron pyrites.

In the year 1815, an individual succeeded in getting a company formed and incorporated with a capital of eighty thousand dollars, called the Easton lead and silver mining company. The fruits of their labor may be seen in an excavation, in red granite nearly one hundred feet deep, at present nearly filled with water. I could not find a particle of ore, of any kind, in the fragments blasted out. A final stop was put to the work, by the killing of two men in blasting.

Forty years since, a shaft was sunk in Mendon, in search of the precious metals. A little specular oxide of iron occurs at the place.

Not many months since an individual called upon me, with specimens of black blende or sulphuret of zinc, found in a neighboring town, and which he strongly suspected to be silver. I informed him of its true nature, and seeing that the vision had got strong hold upon his mind, I did all in my power to persuade him not to engage in searching for the ore. But the only effect was to stimulate him to commence an exploration with more ardor. The zinc was found in a loose piece of rock lying in the field. The man's impression was, that even if that ore was of no use, it indicated something valuable beneath. Accordingly he commenced digging. Ere long, his faith was strengthened, by some one's discovering a light, during the darkness, near the spot; and the last time I heard from the man, he had penetrated the soil about seventy feet.

The following case has been stated to me on such authority that I do not doubt its correctness.

Some forty or fifty years ago, a farmer, residing not far from the centre of Massachusetts, knocked off from a rock upon his farm, a piece of ore, which he sold in Boston for a considerable sum, as a rich ore of silver. From that time till the day of his death, he searched in vain for the rock from which it was broken. The inference which he drew from his ill success, was, that Satan, (who is thought, by multitudes, to have unlimited power over the mineral treasures of the earth,) had concealed or removed the precious vein. Conceiving, however, that some of his posterity might have more interest with that personage than himself, he reserved to the right of digging the ore, in the instrument which conveyed away his title to the land. His posterity were not forgetful of the reservation; but they were convinced it would be of no use to them, unless they could meet with some individual who had *entered into a league*, (as the phrase is with the class of people whom I am describing,) with his Satanic majesty. Last year they heard of such a man, a German in Pennsylvania, who had obtained possession of a wonderful glass, through which he could discover whatever lies hid beneath the soil. The German was persuaded to visit the spot, and when I passed through the place, a little more than a year ago, an excavation was about to be commenced under his direction. And I have since been told that the work was prosecuted till the owner's property was well nigh expended.

Still more ridiculous than the opinions and practices above mentioned, are some still existing in a few places in the State, relative to deposits of money, said to have been made by one Kidd, a celebrated buccaneer of early times. The statement is, that he frequently ascended our streams a considerable distance, and buried in their banks, large sums of money. These are supposed to be guarded with sleepless vigilance by the personage mentioned before. But by the use of certain incantations, while digging for the treasure, it may be wrested out of his hands: for instance, perfect silence must reign during the operation, unless it be broken by the reading of the Bible, and all must be done in the night. The last instance of the practice of this mummery, which I have heard of, occurred a few years since on one of the branches of Westfield river. A hundred days' work were expended upon the enterprise before it was abandoned. At one time those employed in this work were greatly discouraged, by the intrusion of my informant, who, in spite of all they could do by gestures, broke silence and thus dissolved the charm. At another time, courage was revived by finding an iron pot, containing some bits of copper, deposited there, the day previous, by some boys, who had learned what was going forward.

I have given these rather mortifying details, partly because I doubt whether one tenth of our population are aware of the existence of such opinions and practices among us; and partly in the hope that the exposition may be instrumental in entirely eradicating them from the minds of those who have been thus deluded. For, like night fogs, they need only to be brought into the light of day to be dissipated.

Concluding Remarks.

In concluding this summary of the economical geology of Massachusetts, I cannot but allude to the very imperfect developement which has hitherto been made of our mineral resources. Judging from what we know at present, our granites, marbles, and other rocks, useful in architecture, are undoubtedly the richest of these resources. Yet it is only a few years, since these rocks (with the exception of some quarries of marble,) have been employed at all for building; and even now, only a few beds, and these very possibly not the best, have been opened. In the vicinity of Connecticut river, the inhabitants are just beginning to learn that they have beautiful granite in their own hills and mountains. The Berkshire marbles are wrought on a stinted scale, compared with what they might be, were a railroad to furnish the means of an easy transportation to the Hudson. And as to our porphyries and serpentines, various and abundant as they are, it is rare to meet with a single polished specimen. Our mineral veins and beds, with the exception of a few mines of iron, and one of lead, lie as yet almost untouched, and probably many of them undiscovered.

These facts ought to be kept in mind in forming an estimate of our mineral resources. Yet imperfect as is our acquaintance with these, I think we need not fear a comparison, in this respect, with any other part of the country. Other states possess particular minerals which are more valuable and interesting, and calculated to awaken public attention more than ours; yet where is the teritory abounding in a greater number of rocks and minerals, of real and permanent utility, whose quality is excellent and whose quantity is inexhaustible? They are, indeed, of such a character, that they will increase in value for several generations to come. That is, we may calculate that the demand for them will increase during that period, and this demand will lead to the discovery of varieties really more valuable.

Thus far we have regarded our geology only in an economical point of view. I hope to show in the subsequent parts of my Report, that it is not less interesting to the man of taste and science.

Respectfully submitted,
EDWARD HITCHCOCK.

Amherst College, Jan. 1, 1832.

TOPOGRAPHICAL GEOLOGY.

PART II.

To His Excellency Levi Lincoln, Esq.
Governor of Massachusetts.

I have supposed that my account of the Geology of the State would be quite imperfect, without some notice of our Scenery. Strictly speaking, indeed, scenery is not geology: and yet the contour of a country owes its peculiarities in a great measure to the character of the rocks found beneath the soil: so that the geologist, by a mere inspection of the features of the landscape, can form a very probable opinion of the nature of the rock formations. The extended plain, he will pronounce alluvial, or tertiary. The precipitous ridge or mountain, if dark colored, will indicate trap rocks; if light colored, granite: if the summit be rounded, and the aspect red or gray, he will suspect it to be made up of sandstone. The more extended and less precipitous mountain ranges, stretching away over many a league, correspond more nearly to the outlines of primary rocks. In short, the connection between the aspect of the earth's surface and the nature of the rocks beneath, is so obvious, that I have thought it would not be a misnomer, to denominate an account of the natural scenery, *Topographical Geology*. In the following sketch of the scenery of Massachusetts, my principal object will be to direct the attention of the man of taste to those places in the State, where he will find natural objects particularly calculated to gratify his love of novelty, beauty and sublimity. I have not the space, had I the ability, to describe them with the vividness and fullness of the poet or the painter. But by sketching their obvious features, I would hope to induce gentlemen of leisure and intelligence, who are lovers of the beautiful, the sublime, and the picturesque in nature, to visit and more minutely to describe them.

The most striking objects in the scenery of a country, where they exist, are high and precipitous mountains; especially if extensive plains, traversed by rivers, stretch away from their bases. I shall, therefore, in the first place, describe, those conspicuous peaks and ridges in the State, whose summits afford wide and interesting prospects.

Massachusetts is peculiarly mountainous. But mountain scenery is not particularly interesting, if the slopes are gentle, and the outlines of the hills are much rounded. It needs the sharp towering peak, the craggy and overhanging cliff, and the roaring torrent beneath, to arrest the attention, and excite strong emotions. Such objects are numerous in this State, especially in the western part. Here we find some scenery that is truly Alpine. I begin with the highest point in the State, viz.

Saddle Mountain.

We have in Massachusetts three lofty and extensive ranges of mountains, crossing the State in a north and south direction. The summit of the Taconic Range, corresponds nearly with the west line of the State. The Hoosic Range is separated from the Taconic by a valley several miles in width. It occupies all the eastern part of Berkshire county, and the western part of Franklin, Hampshire and Hampden; being from 30 to 40 miles broad, and extending easterly to the valley of the Connecticut. East of this valley is a belt of mountainous country, embracing the eastern part of Franklin, Hampshire and Hampden counties, and the whole of Worcester county: but no specific name has been applied as yet to this range as a whole.

Saddle Mountain does not belong, properly speaking, to any of these chains of elevated land; though generally regarded as a spur from the Hoosic range. But it is in fact an insulated eminence, mostly in the town of Adams, and nearly surrounded by vallies, above which it rises 2,800 feet, and nearly 3,600 above the tide water of the ocean. It is chiefly the insulated character of this mountain, that renders it so striking an object in the scenery. Its summit is supposed to bear a resemblance to that of a saddle; and hence its unpoetic name. The highest point of the summit has a much more appropriate designation, viz. *Graylock;* from the hoary aspect which the upper part of the mountain presents in the winter months. During that season, the frost attaches itself to the trees, which, thus decorated, it needs no great stretch of imagination to regard as the gray locks of this venerable mountain. As the cold increases, the line of congelation sinks lower and lower, covering more and more of the mountain with frost work, and a contrary effect results from an increase of the temperature; so that this line is frequently rising and falling during the cold months, producing numerous fantastic changes in the aspect of the mountain.

The best route by which to ascend to the summit of Graylock, passes up the southwestern declivity of the mountain, through what is called the *Hopper;* and over that spur of the mountain denominated Bald Mountain. The ascent is so gentle that it may be gained on horseback. Indeed, in one instance I was told that a lady, accustomed to equestrian excursions, reached the summit in this manner: and were the road in the upper part improved as it might be, by a little labor, her example might be easily followed. Another improvement, also, should be made before ladies are invited to take this excursion. At present one is obliged to climb a tree, to the height of 30 or 40 feet, in order to get an unobstructed view from the summit; so that either the surrounding trees should be cleared away, or a stone or wooden structure be erected, that would overlook them.

I know of no place where the mind is so forcibly impressed by the idea of vastness, and even of immensity, as when the eye ranges abroad from this eminence. Towards the south you have a view, more or less interrupted by spurs from the Taconic and Hoosic ranges of mountains, of that fertile valley which crosses the whole of Berkshire county. On your right and left, you look down upon, or rather overlook, the Taconic and Hoosic mountains; which from the valley beneath, seem of such towering height and grandeur. Beyond these mountains, on every side, you see the summits of peak beyond peak, till they are blended with the distant sky. The objects in the immediate vicinity of the mountain do not forcibly arrest the attention; though from the northern point of the summit, I should suppose the valley of Williamstown must be delightfully exhibited. Still, the vast depth of the valley around you, as you stand upon Graylock, contributes no doubt to swell the feeling of immensity and sublimity produced by looking abroad among such a sea of mountains.

Upon the whole, however, I was more interested by the phenomena exhibited in that part of the mountain called the Hopper, than by a view from the summit. As the traveller descends from Graylock, let him follow out the naked summit of Bald Mountain nearly to its extremity, and then, on turning northerly, he will find before him a gulph at least a thousand feet deep, the four sides of which seem (although it is not strictly so) to converge to a point at the bottom. The slope of these sides, is so steep, that one feels dizzy on looking into the gulph. These slopes are all covered with trees of various species, among which are occasional patches of evergreens, giving to the whole a rich and captivating appearance. On the northeast side, however, may be seen the traces of several *Mountain Slides*, by which the trees and the loose soil have been swept away from the height, in some cases, of 1600 feet, and of considerable width. It is not more than six or eight years since one or two of these slides occurred; and the paths which they left behind, are yet entirely naked of vegetation. In some instances of earlier date, we perceive the vestiges of the avalanche, only in the stinted growth, or peculiar character of the trees, that have sprung up. It is said that one of the most remarkable of these slides, took place in the year 1784; and that one dwelling house was swept away by the inundation, though the inmates escaped.

Scattered through the valley of Berkshire and among the high ranges that bound it on either hand, are many other mountains and peaks that present delightful and extensive landscapes from their summits. There is, however, such a general resemblance in the scenery of the county, that a particular description of each prospect will be unnecessary, after what has been said of Saddle Mountain. In the southern part of the county, the Taconic range reaches a height not much inferior to that of Graylock. That part of the range is called,

Mount Washington.

It lies in the southwest corner town of the State, (except a small triangular unincorporated tract at the very angle of the State called Boston corner,) and as it occupies most of the town, both have the same name. It has two principal peaks; the highest and most northerly of which, rises 2400 feet above the valley of the Housatonic, and 3150 above the ocean. The summit of the ridge is mostly naked rock, with even very little shrubbery. The ascent is easy on the easterly side, and the view of the plain of Sheffield and the valley of the Housatonic generally, is delightful.

A somewhat interrupted range of mountains extends from Stockbridge through the easterly part of Great Barrington and Sheffield, presenting several distinct peaks, which have different names, such as Monument Mountain, in Stockbridge, and Alum Hill, in Sheffield. Beartown Mountain extends from Stockbridge through Great Barrington into Tyringham; Rattlesnake Hill is an insulatted mountain in Stockbridge. The mountain separating West Stockbridge from Stockbridge, and Richmond from Lenox, is denominated at its northern part, Lenox Mountain: and more southerly, Stockbridge Mountain. In Washington, and extending into

Pittsfield, is a lofty and rounded spur from the Hoosic range, called Washington Mountain; a name too much like Mount Washington. In Canaan, Connecticut, a few miles beyond the Massachusetts line, is a noble mountain ridge with a mural front on the southwest, and several miles in extent, called Canaan Mountain. From all these mountains, and others that might be named, magnificent prospects are presented, which, in the midst of a general resemblance, exhibit so much peculiar to each, as amply to repay the traveller for climbing them all.

The same may be said of numerous distinct summits that crown the broad ranges of the Taconic and Hoosic. It is extremely exhilarating to the spirits of the tasteful traveller, as he traverses these regions, especially in summer, to find such a constant variety of landscape attending every change of place. For every new hill that he climbs, he is rewarded by the discovery of some new grouping of the distant mountains; some new peak or ridge rising fantastically in the horizon; some new village crowning the distant hill with its neat white houses and church spire; or some hitherto unseen valley opens before him, through which tumbles the mountain torrent; while the vast slopes of the valley present so much diversity, softness, and richness of foliage, as to form a lovely resting place for the eye.

In such mountainous regions it was natural for the first settlers to select elevated situations for a residence. Hence in many instances the tops of these ridges are crowned with many pleasant villages. Among those which are thus situated and afford the most romantic prospects, may be named Blanford, Granville, Tolland, Chester, Middlefield, Peru, Windsor, Chesterfield, Goshen, Cummington, Plainfield, Ashfield, Hawley, Shelburne, Rowe, Heath, and Leyden. To one accustomed to reside in a valley, it is interesting to witness in one of these places, the setting, but more particularly the rising of the sun: when very probably he will see a dense fog resting upon the vallies below, and shutting out the sun, while it shines in all its glory upon the hills around the observer.

In the elevated region east of Connecticut river, a still larger number of villages have been built upon heights commanding wide horizons: and some these, being in a superior style of architecture, are most attractive objects to the distant traveller. What for instance can be a finer object, than the beautiful village of Leicester, seen at the distance of six or eight miles! or than Shrewsbury, Grafton, Charlton or Rutland! Similarly situated are Dudley, Sutton, Mendon, Hopkinton, Spencer, New Braintree, Hardwick, Barre, Petersham, Shutesbury, New Salem, Templeton, Winchendon, Princeton, Westford, Andover, &c. The extent and beauty of the summer prospect from the last mentioned place have long been the admiration of the traveller.

Mount Holyoke.

We come now to the valley of the Connecticut, where is some of the boldest and most beautiful scenery in the State. Mount Holyoke in Hadley claims the first notice; not on account of its superior altitude, for it is only 830 feet above the Connecticut at its base, and about 900 above Boston Harbor; but on account of its peculiar position in respect to interesting objects around. It is a part of a mountain ridge of greenstone, commencing with West Rock, near New Haven, and proceeding northerly, interrupted only by occasional vallies, across the whole of Connecticut, until it enters Massachusetts between West Springfield and Southwick, and proceeds along the west line of the first named place, and along the east line of Westfield, Easthampton, and Northampton, to the banks of the Connecticut. Until it reaches Easthampton, its elevation is small. But there it suddenly mounts up to the height of nearly a thousand feet, and forms Mount Tom. The ridge crosses the Connecticut, in a northeast direction, and curving still more to the east, passes along the dividing line of Amherst and South Hadley, until it terminates ten miles from the river in the northwest part of Belchertown. All that part of the ridge east of the river, is called Holyoke: though the prospect house is erected near its southwestern extremity, opposite Northampton, and near the Connecticut. And that is undoubtedly the most commanding spot on the mountain, though several distinct summits, that have as yet received no uniform name, afford delightful prospects. It is not generally known, indeed, how a slight change of situation upon a mountain, will often put an almost entirely new aspect upon the surrounding scenery. A knowledge of this fact, might often give a tenfold duration to the pleasure of the observer. The man who means to feast to the full upon mountain, scenery, should be accoutred in such a manner that he can turn aside from the beaten track, urge his way through the tangled thicket, and climb the craggy cliff. There is a peculiar pleasure, which such a man only can experience, in feeling that he has reached a point perhaps never trodden by human foot, and is the first of the rational creation that ever feasted on the landscape before him.

In the view from Holyoke we have the grand and the beautiful united; the latter, however, greatly predominating. The observer finds himself lifted up nearly a thousand feet from the midst of a plain which, northerly and southerly, is of great extent; and so comparatively narrow is the naked rock on which he stands, that he wonders why the winds and storms of centuries have not broken it down. He soon, however, forgets the mountain beneath him, in the absorbing beauties before him. For it is not a barren unenlivened plain on which his eye rests; but a rich alluvial valley, geometrically diversified in the summer with grass, corn, grain, and whatever else laborious industry has there reared. On the west, and a little elevated above the general level, the eye turns with delight to the populous village of Northampton; exhibiting in its public edifices, and private dwellings an unusual degree of neatness and elegance. A little more to the right, the quiet and substantial villages of Hadley and Hatfield, and still farther east and more distant, Amherst with its College, Gymnasium, and Academy, on a commanding eminence, form pleasant resting places for the eye. But the object that perhaps most of all arrests the attention of the man of taste, is the Connecticut, winding its way majestically, yet most beautifully, through the meadows of Hatfield, Hadley, and Northampton; and directly in front of Holyoke, as if it loved to linger in so tranquil a spot, it sweeps around in a graceful curve of three miles extent, without advancing in its oceanward course a hundred rods. Then it passes directly through the deep opening between Holyoke and Tom, which its own waters, or more probably, other agencies have excavated in early times. Below this point, the Connecticut is in full view, like a serpentine mirror, for nearly twenty miles. And through a deception, explicable by the laws of perspective, there seems to be a gradual ascent of the river, the whole distance, till at its vanishing place it seems elevated nearly to a level with the eye: just as the parallel sides of a long avenue seem to approach nearer until they meet.

The valley on the south of Holyoke is not as interesting as that on the west and north; chiefly because the land is less fertile. The village of South Hadley is indeed a pleasing object. But Springfield, one of the lovliest spots in America, is too far removed for an exhibition of its beauty. Other places south of Springfield are indistinctly visible along the banks of the Connecticut: and even the spires of some of the churches in Hartford, may be seen in good weather, just rising above the trees. Still farther south in that direction, may be seen the abrupt greenstone bluffs midway between Hartford and New Haven; and looking with a telescope between these, other low hills may be indistinctly seen, which may be the trap ridge encircling New Haven.

Facing the southwest, the observer has before him on the opposite side of the river, the ridge called Mount Tom, rising one or two hundred feet higher than Holyoke, and dividing the valley of the Connecticut longitudinally. The western branch of this valley is bounded on the west by the eastern slope of the Hoosic range of mountains; which, as seen from Holyoke, rises ridge above ridge for more than twenty miles, chequered with cultivated fields and forests, and not unfrequently enlivened by villages and church spires. In the northwest the Graylock may be seen peering above the Hoosic; and still farther north, several of the lofty peaks of the Green Mountains (which are merely a continuation of the Hoosic,) shoot up beyond the region of clouds, in imposing grandeur. Nearer at hand and in the valley of the Connecticut, the insulated Sugar Loaves and Toby present their fantastic outlines: while far in the northeast stands in insulated grandeur the cloud-capt Monadnoc.

Probably under favorable circumstances, not less than 30 churches, in as many towns, are visible from Holyoke. The north and south diameter, of the field of vision there, can scarcely be less than 150 miles.

The Columns.

Less than a half a mile south of the road leading to the prospect house on Holyoke, and in the western face of the ridge, may be seen some interesting examples of greenstone columns. They stand side by side to the height of many feet, and as the lower part of the outer ones has fallen down, their curiously formed tops project from the cliff and seem to threaten the observer with destruction. In the third part of my Report I shall describe these columns more particularly. But I think they must prove attractive to every one to whom a visit to the top of the mountain, is interesting. The visitor, however, must not expect a very smooth path in reaching them; for he must clamber over a large amount of *debris*, sloping at an angle of 45°.

Titan's Pier.

Standing upon Holyoke and facing the south, one has directly before him, and as it were under his feet, the deep gorge between Holyoke and Tom, through which Connecticut river passes. Following the western side of the mountain, as it rapidly descends to the river, we find it terminating with a naked rock extending several rods into the river, and nearly perpendicular on the side next to the water, from 20 to 100 feet high. A considerable part of this naked rock exhibits a columnar structure; not in general as perfect as the spot above described, yet sufficiently regular to require little aid from the imagination, to be regarded as artificial; though obviously demanding giant strength for its construction. I have said that the columnar structure was not in general very perfect. But if one can work his way along the western face of this precipice at low water, he will find, near where the rock passes under the river, the tops of numerous columns of great regularity; their upper portions have been removed by the force of the stream, which for so many centuries has been battering this cliff with logs and ice. By referring to the next part of my Report, a more definite idea can be obtained of these columns. But from what I have now said, every intelligent man will perceive that they are very similar to those on the coast of Ireland, which form *Fingal's Cave* and the *Giant's Causway*. The nature of the rock too, is essentially the same in all these places. Why then may I not be permitted to denominate this rock, *Titan's Pier?* At least, may I not hope by this description to attract the attention of visitors to Holyoke to this spot? Hitherto it has been passed unnoticed.

Mount Tom.

As this is higher than Holyoke, and insulated in the same great valley, the view from its summit cannot but be commanding; yet most of the interesting group of objects around the base of the former, is wanting around the latter. Hence Tom is not much frequented; while during the summer months, Holyoke is a place of great resort.

I obtained from this mountain one summer morning, a striking view, while yet the whole valley of the Connecticut was enveloped in fog, and Tom with a few other elevated peaks connected with the greenstone range, alone rose above the vapor. The sun shining brightly and the wind gently blowing, gave to this fog a strong resemblance to an agitated ocean. To the north and south it seemed illimitable; but on the east and the west, the high mountain ranges that form the boundaries of the valley of the Connecticut, constituted its shores. I could not but feel transported back, to that remote period, when this great valley was enveloped in like manner, by water, and Holyoke and Tom formed only low and picturesque islands upon its surface.

Sugar Loaf Mountain.

No object in the valley of the Connecticut, is more picturesque than this conical peak of red sandstone, which rises almost perpendicularly 500 feet above the plain on the bank of the Connecticut, in the south part of Deerfield. As the traveller approaches this hill from the south, it seems as if it summits were inaccessible. But it can be attained without difficulty on foot, and affords a delightful view on almost every side. The Connecticut and the peaceful village of Sunderland on its bank, appear so near, that one imagines he might almost reach them by a single leap.

This mountain overlooks the site of some of the most sanguinary scenes, that occurred during the early settlement of this region. A little south of the mountain the Indians were defeated in 1675 by Captains Lathrop and Beers: and one mile northwest, where the village of Bloody Brook now stands, (which derived its name from the circumstance,) in the same year, Captain Lathrop, was drawn into an ambuscade with a company of 'eighty young men, the very flower of Essex County,' who were nearly all destroyed.

Deerfield Mountain.

A sandstone ridge commences at Sugar Loaf, and runs northerly through Deerfield and Greenfield, into Gill, increasing in height as far as the village of Deerfield, where it is 700 feet above the plain on which that village stands. Standing near this point, on the western edge of the mountain, a most enchanting panorama opens to view. The alluvial plain on which Deerfield stands is sunk nearly 100 feet below the general level of the Connecticut valley; and at the southwest part of this basin, Deerfield river is seen emerging from the mountains, and winding in the most graceful curves along its whole western border. Still more beneath the eye is the village, remarkable for regularity, and for the number and size of the trees along the principal street. The meadows, a little beyond, are one of the most verdant and fertile spots in New England. Upon the whole, this view is one of the most perfect pictures of rural peace and happiness that can be imagined.

Mount Toby.

This is a sandstone mountain of not less elevation than Mount Tom; and it is separated from Sugar Loaf by Connecticut river, lying partly in Sunderland and partly in Leverett. It is separated also by a deep valley from the primitive mountains near it on the east. It is a noble mountain, and as yet, is almost covered by forests. The view from its summit is commanding, but it embraces no objects of peculiar and special interest.

It has frequently been stated, and that too by very respectable authority, that the ridges forming East and West Rock, Holyoke, Toby, &c., are a part of the broad ranges, which, commencing at Long Island Sound, rise gradually towards the north into the Hoosic and Green Mountains on the west side of Connecticut river, and into Monadnoc and the White Mountains on the east side. But a slight knowledge of the geological character of these mountains, is sufficient to show that the trap and conglomerate ridges along the Connecticut, differ, *toto coelo*, from the primary ranges on either side. And a slight examination of the topography of these mountains, shows that the former are uniformly separated by deep vallies from the latter, and have no geographical connection except proximity.

What a pity it is, that so many of the most interesting mountains and hills in Massachusetts have got attached to them such uncouth and vulgar names! How must the poets lines

> ——————scramble up and down
> On disproportioned legs, like Kangaroo,

if such words as Saddle Mountain, Rattle Snake Hill, Bear Town Mountain, Mount Tom, Mount Toby, Sugar Loaf, Blue Mountain and Deerfield Mountain, be introduced. Holyoke, Taconic, Hoosic and Wachusett, are more tolerable; though most of them have an Indian origin. It would have been fortunate, if our forefathers had not attempted in general to supersede the aboriginal designations. For what mountain can ever become an object of much regard and attachment, if its beauties and sublimities cannot be introduced into a nation's poetry, without producing the most ridiculous associations! Fortunately there are some summits in the State yet unnamed. It is to be hoped that men of taste, will see to it, that neither Tom, nor Toby, nor Bears, nor Rattle Snakes, nor Sugar Loaves, shall be *Saddled* upon them.

In the eastern part of the State, the interesting mountains are few: The loftiest and most striking is

Wachusett.

This mountain is in Princeton, whose general elevation, above the ocean, is 1100 feet: and the mountain lifts its conical head 1900 feet higher, so as to be 3000 feet above Massachusetts Bay. The ascent on foot is not difficult. From the summit, which is little more than naked rock, the eye takes in a vast extent of country on every side. On the east and south the distant hills are comparatively low, and seem to possess an even outline. On the west and northwest, mountain ridges and peaks succeed one another, becoming more and more faint, until the distant Hoosic and Green Mountains fade away into the blue heavens. Several neat villages around the base of this mountain with numerous ponds of considerable extent, give an interesting variety and liveliness to the picture. Probably more of Massachusetts may be seen from this mountain than from any other in the State. It attracts numerous visitors, and a small square wooden tower has been erected on the top.

Blue Hills.

This is the highest and most conspicuous range of hills in the vicinity of Boston. It is most elevated at its western extremity, in the southwest part of Milton, where it rises 710 feet above the ocean. A little to the southeast, and just within the limits of Quincy, the summit is elevated 680 feet. Still farther east it is 570 feet. Northeast a little from this peak, is another 530 feet high. The Monument Quarry in the northeast part of these hills, is 390 feet high; and Pine Hill, to the southeast of this quarry, is 235 feet high. All these summits command extensive and most interesting prospects. And there are some circumstances that impart to these landscapes peculiar interest. One is the proximity of these hills to Boston; whose numerous edifices, masts, spires, and towers, and, nobly peering above the rest, the dome of the State House, present before the observer, a most forcible example of human skill and industry, vieing with, and almost eclipsing nature. And the high state of cultivation exhibited in the vicinity of Boston, with the numerous elegant mansions of private gentlemen, crowning almost every hill, and imparting an air of freshness and animation to the valley and the plain, testify how much taste and wealth can do in giving new charms to the face of nature.

From these hills the observer has also a fine view of Boston Harbor; and this is another circumstance of peculiar interest. For to look out upon the ocean is always an imposing sight; but when that ocean is studded with islands, most picturesque in shape and position, and the frequent sail is seen gliding among them, he must be insensible indeed, whose soul does not kindle at the scene, and linger upon it with delight.

On Monument Hill, is opened perhaps the largest of the quarries of Quincy granite; and from thence a rail road (the only one of much extent yet existing in Massachusetts,) runs directly to Neponset river: and this is another circumstance of peculiar interest to the visitor of these hills. Let him ascend the granite tower, which the proprietors of the quarry have erected on its site, and he will have before him, not merely the rich variety of natural and artificial objects above descibed, but this railway, also, stretching away for miles in a right line towards the river, with here and there the cars going and returning. Such conveyances, however, will soon cease to be a novelty in Massachusetts.

Many other hills of moderate altitude around Boston, particularly on the south of the city, might be mentioned as a worthy of a visit for the prospects presented from their summits. The heights of the following are given on Hale's beautiful 'Map of Boston and its vicinity.'

In Quincy, near the Common,		210 feet
do.	One mile north,	175
do.	A half mile farther north,	107
do.	A little N. W. of Hon. J. Quincy's seat,	40
do.	Great Hill, near the eastern extremity of the town,	94
do.	Squantum,	99
In Braintree, near the east line,		205
In Weymouth, near the west line,		210
do.	Near Town River Bay,	134
In Hingham, N. W. part of the town,		112
do.	On Crown Point,	102
do.	A little N. W. of Mr. Brook's M. House,	107
In Hingham, a little south of Mr. Brook's M. House,		75
do.	Near the east line of the town,	230
In Cohasset, near the west line of the town,		215
do.	A mile south of Nantasket Beach,	175
do.	N. E. part of the town, close to the shore,	110
In Milton, at the Academy,		208
do.	One mile south of this place,	226
do.	A mile west of the last,	217
do.	N. W. part of the town,	216
In Dedham, at Mr. White's M. House,		405
In Dover, Pine Hill, south part,		400
In Waltham, Prospect Hill,		470
do.	Bear Hill,	510
do.	Near the N. E. line of the town,	570
In Lincoln, Dr. Stearn's M. House,		470
do.	Mount Tabor,	370
In West Cambridge, near the S. W. line of the town,		320
In Watertown, N. W. corner,		310
In Charlestown, Prospect Hill,		120
do.	Winter Hill,	120
In Chelsea, Pulling Point,		84
In Lynn, near Phillip's Point,		135
do.	Near King's Beach,	147
do.	A mile N. E. of Lynn Hotel,	120
do.	Half a mile north of " "	125
do.	A mile north of " "	140
In Marblehead, Legg's Hill,		160
do.	Half a mile N. E. from do.	97
do.	Three quarters of a mile N. E. of the last,	105
do.	N. E. part of the town,	135
do.	A little north of the village,	130

In Marblehead, on Marblehead Neck,	137
In Salem, east of Spring Pond,	197
do. N. W. part of the town,	145
do. S. E. part of the town,	175
do. A little west of South Fields.	186

Some of the views from the hills around Salem and those on the promontory of Marblehead, are of an imposing character. The extreme rockiness of the coast and islands strikes the observer at first as evidence of irreclaimable sterility. But when he sees the luxuriant vegetation of every cultivated spot, and the populousness and elegance of Salem and many of the neighboring villages, the contrast increases his pleasure.

Having thus noticed all the important hills and mountains in the State, with reference to views from their summits, I proceed briefly to sketch the picturesque scenery of particular districts. For we have not seen all that is interesting in the scenery of a country, when we have only looked over it from its elevated points. The ever varying prospects which are produced by those elevations, to one winding through the vallies among them, are often of the most romantic character.

The Vallies of Berkshire.

In exemplification of this position, let us suppose an observer to pass from Williamstown southerly through New Ashford, Lanesborough, Lenox, Lee, Stockbride, Great Barrington, and Sheffield. Till beyond New Ashford, he will be following one of the branches of Hoosic river up the valley of Williamstown. On his right rises the broad slope of the Taconic range of mountains; while on his left, and near at hand, Saddle Mountain shoots up in imposing grandeur; and more distant, through a lateral valley, a part of the Hoosic range is visible. If it be spring, these mountain sides exhibit numerous species of trees and shrubs emulating one another in putting on their party-colored foliage; while here and there an Aronia, or a Cornus, is entirely clothed with white blossoms before the appearance of its leaves. If it be summer, these vast slopes are covered from base to summit with a vegetable dress, embracing every hue of green, from the dark hemlock and pine, to the almost silvery whiteness of the white oak and poplar. If it be autumn, that same foliage, now assuming almost every color of the spectrum, and of hues almost as bright, presents one of the most splendid objects in nature.

As the traveller appproaches New Ashford, the hills crowd closer and closer upon his path, which winds among them in conformity with sinuosities of the river; and a succession of romantic and Alpine beauties is constantly opening before him.

Having reached the north part of Lanesborough, he begins to descend into the valley of the Housatonic, which gradually widens before him, and ere he reaches Sheffield, presents to his view a number of most delightful villages, generally in the vicinity of fertile alluvial tracts; while on every side, mountains of various altitudes and of almost every shape, form the outline of the landscape. Where, for instance, does the traveller meet in any part of our land with lovlier spots than Pittsfield, Lenox, Lee, Stockbride, and Great Barrington!

Valley of the Connecticut.

The circumstances that render the scenery of this valley so attractive to the man of taste, are the extent and fertility of its alluvial meadows; the precipitous boldness and irregular outline of its trap and sandstone ranges, already described; and the magnitude and beauty of the Connecticut, and of its principal tributaries, the Westfield and the Deerfield, winding through the secondary basins which their waters or other agencies have produced. Let such a region as this be sprinkled over with villages like Longmeadow, Springfield, West Springfield, South Hadley, Amherst, Sunderland, Northampton, Hadley, Hatfield, Deerfield, Greenfield, and Northfield, and it needs the inspiration of poetry to describe its beauties. Unfortunately, however, the valley of the Connecticut remains yet to be described.

Several of the villages above named are sufficiently elevated to overlook the surrounding region to a considerable extent, though neighboring mountains still tower above them; and thus are combined the beauties and advantages of a location upon a hill, with those to be found in a valley. The upper terrace of Springfield, on which stands the United States Armory, is thus elevated. Still higher is South Hadley, with Holyoke and Tom half encircling it on the west and north, except where the Connecticut has opened a passage between these mountains; serving as a vista through which is disclosed at greater distance the Hoosic range. From the Gymnasium on Round Hill in Northampton is one of the richest views of fertile meadows, and mountains of fantastic shape, to be found in the country. From the Gymnasium at Amherst is a similar prospect; and from the College tower in the same place, one of wider range and more imposing features. From the Seminary in Greenfield, a southern prospect opens of enchanting beauty.

The opening of a new road along the banks of the Connecticut, in the northwest part of South Hadley, has brought to light (I mean, to my own eyes,) a most lovely landscape. Standing on the elevated bank and facing the northwest, you look directly up the Connecticut river, where it passes between Holyoke and Tom; those mountains rising with precipitous boldness on either side of the valley. Through the opening, the river is seen for two or three miles, enlivened by one or two lovely islands, while over the rich meadows that constitute the banks, are scattered trees, through which, half hidden, appears in the distance the village of Northampton; its more conspicuous edifices only being visible. Far beyond, and forming the remote outline of the picture, lies the broad eastern slope of the Hoosic mountains. (See Plate IV.)

Another road has been recently opened on the banks of the Connecticut in the north part of Springfield, a mile or two below South Hadley Canal: and here, too, as you face the northwest, a landscape full of interest opens before you. In full view towards the left hand side of the picture, you have the Falls in the Connecticut and the entrance of the Canal on the north shore. A little to the right of the Canal, a well built village occupies a beautiful ampitheatre, whose elevated border is not less than 150 feet high, and mostly crowned with oakes and pines. Beyond this, at no great distance, however, Mount Tom occupies the back ground with its bold and imposing outline. (See Plate VI.)

Three miles southeast of Sugar Loaf, in Deerfield, that peak presents one of the most unique views conceivable. Its outlines are so regular, that were the traveller to meet with it in Egypt, he might, at first view, regard it as indebted to human art, for its present shape. At any rate, in that country it would probably have been wrought into a second Sphinx, or some other gigantic monster. But to the student of nature it is no less interesting as the work of God. A little to the left, as seen from the place mentioned above, the southern point of the Deerfield Mountain, sometimes called North Sugar Loaf, appears, as well as the bold western front of that range for several miles; and a little to the right, across the Connecticut, Mount Toby is in full view. The sketch, Plate VII., was taken considerably nearer to Sugar Loaf, and differs somewhat from the above description.

Ravine of Westfield River.

Westfield river has found or formed a deep passage across the whole eastern slope of the Hoosic range of Mountains, through the towns of Westfield, Russell, Blanford, Chester, and Middlefield. The ravine through which it passes, is for the most part very deep and narrow, and cuts across, not only the general direction of the mountain ranges, but across the rock strata also.

Hence it might be expected that the sides of this ravine would exhibit wild and interesting scenery. Nor will this expectation be disappointed, if the traveller follows the Pontoosuc Turnpike through this defile. Hills and precipices of every shape will crowd upon his path, now approaching so as so form a narrow gorge, and now gently retiring so as to leave room enough for some industrious farmer to erect his habitation, and gain a subsistence in the deeply embosomed glen. In passing through such a region, the man destitute of taste will be heard speaking only of the roughness, sterility, and gloominess of the country; while the man of taste and sensibility will be absorbed in admiring its beauties and sublimities.

Ravine and Gorge of Deerfield River.

Still more remarkable is the gulf through which Deerfield river passes, in a southeast direction, nearly across the whole of the broad mountain range, between the Connecticut and Williamstown valleys. Perhaps the best route for visiting this ravine, is to take the turnpike road from Greenfield to Williamstown. On this route the traveller will not come upon the banks of the Deerfield, until he reaches the west part of Shelburne: but he will obtain a most delightful view of Greenfield, as he ascends the high hills west of that place; and as to the defile, through which Deerfield river runs between Shelburne and Conway, it is so narrow, and the banks, of several hundred feet in height, are so steep, that it is difficult even on foot to find a passage; though full of romantic and sublime objects to the man who has the strength and courage to pass through it. From the west part of Shelburne, however, to the foot of the principal ridge of Hoosic mountain in Florida, a good road leads along the banks of the stream; though in a few places hard pressed between the hill and the river. In one spot it is actually sustained a hundred feet above the river, upon piles driven into the steep and naked declivity of a mountain slide. But through nearly the whole of Charlemont, the hills recede so far from the river, as to form an alluvial valley of considerable width and fertility. The loftiness of these hills, however, and the frequent openings of lateral ravines, through which the small tributaries of Deerfield river disembogue, keep the attention of the tasteful man awake. As he goes westward, these hills approach nearer and nearer to the river, become bolder in their outlines, and steeper in their declivities, till at length, in Zoar and Florida, they shoot up, sometimes a thousand feet high, in a variety of spiry and fantastic forms, and the traveller, as he looks forward, can often see no opening through which the river can find its way. The murmuring of its waters, however, at the bottom of the gulf, sometimes swelling into a roar, as they rush through some narrow defile, tell him that they have found a passage. At length the road leaves the river, and ascends the ridge, which in the vicinity is alone denominated Hoosic Mountain, and which is here 1448 feet above the river. It is well to follow this road at least to the height of a thousand feet, in order to look back upon the wild and singular grouping of mountains, among which this river has strangely found a passage; and also to get a view of some of those vast slopes of unbroken forest, which the sides of these mountains present; and which during the twilight, are most splendid objects.

In two or three instances it has happened that I have passed along this ravine in the evening, when the moon was well above the horizon; and I can truly say, that the wildness and sublimity of the scene were thereby immensely heightened; so that I felt it to be a privilege to be thus benighted.

Near the mouth of Deerfield River, in Deerfield, is a remarkable gorge through which that stream empties into the Connecticut. A greenstone ridge of 300 or 400 feet in height, has been cut through in some way or other, in width only sufficient to suffer the river to pass. This pass is in full view from the stage road between Deerfield and Greenfield where it crosses Deerfield river.

Valley of Worcester.

Apart from human culture, this geographical centre of Massachusetts would present no very striking attractions to the lover of natural scenery. But this valley possesses precisely those features which art is capable of rendering extremely fascinating. And there is scarcely to be met with, in this or any other country, a more charming landscape than Worcester presents, from almost any of the moderately elevated hills that surround it. The high state of agriculture in every part of the valley, and the fine taste and neatness exhibited in all the buildings of this flourishing town, with the great elegance of many edifices, and the intermingling of so many and fine shade and fruit trees, spread over the prospect beauty of a high order, on which the eye delights to linger. I have never seen, in a community of equal extent, so few marks of poverty and human degradation as in this valley. And it is this aspect of comfort and independence among all classes, that enhances greatly the pleasure with which every true American heart contemplates this scene; since it must be considered as exhibiting the happy influence of our free institutions.

Valley of the Merrimack.

The scenery along this river is characterized by beauty rather than sublimity. The hills and mountains are rarely precipitous or very lofty: but generally of gentle ascent and capable of cultivation to their summits. The attractions of the landscape consist of a noble river, beautiful villages, and well cultivated fields and meadows. To the man who loves to see natural scenery modified by human culture, and on every side the marks of an intelligent and happy population, with manufacturing establishments uncommonly flourishing, a ride down this stream on either bank, cannot but be highly interesting. And when he approaches the ocean, let him enter Newburyport from the north, across the chain bridge, and he will have before him a delightful view of one of the most beautiful towns in New England. And if he wishes still farther to witness the riches of the surrounding scenery, let him ascend the tower of the fifth church in that place, and a wide scene of beauties on the land and the sea—natural and artificial—fills the circle of his vision.

Boston Harbor.

Let no man imagine that he has seen all that is interesting in the scenery of Massachusetts, until he has made an excursion by water in the harbor of Boston, as far at least as the Light House. A city is always an imposing object when seen from the water, especially, if like Boston, its site be considerably unequal and slope towards the observer. But the numerous islands in this harbor, some of them exceedingly picturesque and even unique in appearance, constitute no small part of the attractions of this delightful excursion.

View from the State House.

Upon the whole there is not a more magnificent prospect in Massachusetts, than that from the dome of the State House in Boston; and it will bear a comparison, it is said, with the most celebrated views of a similar kind in Europe. This noble building stands upon Beacon Hill, the highest spot in Boston; and the lantern upon its dome is about 200 feet above the harbor. From this elevation the whole of Boston, with its wharfs, shipping, and public edifices; all the islands in its harbor; the shores of the harbor lined with villages and cultivated fields; and within a circle of ten miles, not less than twenty villages, containing, with Boston, more than 120,000 inhabitants, are here surveyed at a glance. Almost every dwelling of this numerous population, is, indeed, visible: and it is rare to see in a circle of so small extent, as many edifices so elegant; and so few that indicate extreme poverty and wretchedness. So richly cultivated is the vicinity of Boston, that it has the appearance of a vast garden. Yet we do not see here the traces of that vandal spirit, which, in so many parts of our land, is making sad havoc with our groves and shade trees; but enough have been spared or planted in this vicinity to give a refreshing and luxuriant aspect to the scenery.

The political and moral considerations which irresistibly force themselves on the mind when contemplating such a scene, cannot fail greatly to increase the pleasure of the observer. What a drawback upon that pleasure must it be, when the traveller is compelled to say, as he cannot but say, when gazing on a large proportion of the interesting scenery of the eastern continent,

'Art, glory, freedom fails, though Nature still is fair.'

On the contrary, how refreshing to the benevolent spirit, as it surveys from this eminence the dwellings of 120,000 human beings, to be assured that there is not a slave among them all; and that could the eye take in every part of the commonwealth, it would read on every door post the inscription, 'all men are born free and equal;' a maxim which exerts a talismanic influence in defending the feeblest inmate against oppression. Nor should the observer forget, that this same maxim forms the basis of every law originating from the edifice on which he stands; and that it is not licentious liberty that is here enjoyed; but liberty guarded by law, and sustained by law: and that it is the general prevalence of knowledge and virtue in the community, that renders it possible to sustain a proper balance between liberty and law. Foreign nations may predict that our beautiful republican system will be ephemeral. It will, indeed, pass away, whenever unprincipled ignorance shall be permitted to bear sway. But so long as intelligence and moral principle predominate in the community, the ark of liberty is safe. At any rate, it is certain that we do now enjoy the blessings of freedom, and the means, widely diffused, of intellectual, moral, and religious cultivation. As a consequence, contentment, competence, and happiness, are found even among the lowest classes in the community. The traveller of a benevolent heart will rejoice to see, as he wanders over the hills and valleys of our commonwealth, how very few in the community have not all the essential means of human happiness within their reach. He need not fear being detained for days in the wildest and most secluded parts of the State. For scarcely will he find the hut, where if really needing shelter, he will not find a welcome, and all that a temperate man needs to make him comfortable. A man who has frequently been thrown into such situations, or in other words, has had opportunity to learn the character and circumstances of the lowest as well as the highest classes in our community, will find his pleasure greatly heightened in surveying our scenery. Let us hope that succeeding travellers, through many generations, may not be deprived of this same happiness; and instead of indulging in gloomy predictions of the downfall of liberty, let every man strive to form and retain that intellectual, moral, and religious character, which is its only effectual support.

But I fear that I am wandering beyond my appropriate sphere, by these remarks. I proceed to notice some other objects worthy the attention of the man of leisure and taste.

New Bedford seen from its Harbor.

This flourishing place, already wearing the aspect of a populous city, is seen to great advantage in sailing up its harbor. As the ground on which it is built slopes towards the water, the various objects of interest are thus brought into view, rising above one another in a distinct and pleasing manner.

Narraganset and Mount Hope Bays.

An excursion from Taunton to Newport, Rhode Island, down Taunton river, and Mount Hope Bay, and especially from Providence to Newport along Narraganset Bay, conducts the traveller among scenery of great beauty and loveliness. The fertility of most of the country, the neat villages along the way, the numerous irregular contractions and expansions of these bays, forming capes, isthmuses, promontories, bays and harbors, in miniature; the islands that are occasionally interspersed, and the interesting historical associations connected with that region, conspire to keep the attention alive and to gratify the taste. Mount Hope, the granite watch tower of the celebrated sachem Phillip, still commands a fine prospect of the surrounding region; and we see at once why that sagacious chieftain selected this place for his retreat.

The north and south shores of Massachusetts Bay present much scenery of such a sui generis or peculiar character, as to render it extremely interesting to one accustomed to it. As a general fact, there is so great a contrast in the appearance of the two capes that form this Bay, that a visit to the one, only prepares the way for rendering more interesting an excursion to the other. We will suppose the traveller to start from Boston and first proceed along the north shore of the Bay.

Nahant.

He will not fail to visit Nahant; which will be the first place of peculiar interest he will meet with along this coast. It is a bold rocky promontory, connected by a low sandy neck of land with Lynn: or rather, it consists of two islands connected together, and with the main land, by ridges of sand and pebbles. At low water, a perfectly smooth beach of the finest sand is laid bare, which constitutes the road from the mainland; and this sand is so firmly compacted by the perpetual beating of the waves of the Atlantic, that neither horse nor carriage make scarcely a perceptible impression. Hence the ride becomes a delightful one; and although the promontory itself has a very barren and desolate appearance, yet the singularity of the surrounding scenery, the neatness of the houses, built in a peculiar style, and the wide extent of the horizon, conspire to render the prospect during the summer of a most attractive character. It is a place of great resort in the warmer months, and a steamboat plies daily between this place and Boston. The vicinity of the spacious hotel at Nahant is very interesting to the geologist: but the particular characteristics of the rocks must be deferred to a subsequent part of this Report.

Cape Ann.

I have already spoken of the rockiness of the coast in the vicinity of Salem. As we proceed towards Gloucester, which occupies all of what is properly called Cape Ann, the ledges multiply; and on the Cape the forests are mostly cut down, while the surface is almost literally covered, either with rocks in place, or with bowlders of every size. In the northwestern part of Gloucester particularly, the soil is almost wholly concealed by the countless number of these rounded masses. Over nearly all the Cape, indeed, sienite of every description meets the eye in immense quantities; and the traveller naturally enquires whither the soil has been carried, which must once have covered the rocks; and what mighty flood of waters could have swept over this region with the fury requisite to produce such devastation. Scenery of this kind, would be regarded as extremely dreary, were not the desolation carried to such an extent as to be interesting by its novelty. It is scarcely possible for any man, however little interested in the *bizarre* of natural scenery, to traverse this region for the first time, without having his attention forcibly and constantly directed to the landscape around him. And hence this must be one of the best excursions for those afflicted with ennui, that can be found. More extensive, however, and in general, finely contrasted with the scenery of Cape Ann, is that along the south side of the Bay.

Nantasket Beach and Hull.

Supposing the traveller to start as before from Boston, the long and narrow neck of land connecting the settlement of Hull with the mainland must not be passed unvisited. To say nothing of the rocks, which at the head of this beach constitute almost the entire surface, rivaling even Cape Ann in this respect, and which on the shore present a remarkable and elegant variety of colors, the beach itself, not less than four or five miles in extent, is much more interesting than that leading to Nahant. The Light House and the Brewster and other islands in view, as one advances toward Hull, are picturesque objects; and then the pleasant and sunny situation of the little village of Hull, furnishes a convenient resting place for the traveller.

In proceeding from this beach to Cape Cod, the traveller should not fail to pass along the north shore of Colrasset—the most rocky place perhaps in the Commonwealth.

Cape Cod.

But after passing Duxbury, the region of sand and gravel commences; and to Provincetown, the extremity of Cape Cod, no genuine ledge of rocks appears; although bowlders of every size, over the greater part of the distance, are common.

The dunes or sand hills, which are often nearly or quite barren of vegetation, and of snowy whiteness, forcibly attract the attention on account of their peculiarity: while the numerous windmills and vats along the shore, for the manufacture of salt, are scarcely less interesting to one not familiar with such processes. As we approach the extremity of the Cape, the sand and the barrenness increase; and in not a few places, it would need only a party of Bedouin Arabs to cross the traveller's path to make him feel that he was in the depths of an Arabian or Lybian desert. Very different from Bedouins, however, will he find the population of Cape Cod. In the midst of the sands he will find many an oasis, where comfortable and not unfrequently pleasant villages have sprung up, inhabited by a people of mild and obliging disposition, and not deficient in intelligence. A large proportion of the houses on the Cape are, indeed, but one story high. Yet they are for the most part convenient and comfortable; exhibiting the marks of a thrift and independence which one would not expect, when he considers eral the general barrenness of the landscape. I could name sev- parts of Massachusetts, where the marks of poverty are far more striking than on Cape Cod.

The sand is so yielding that the traveller will find it more convenient to leave his carriage 20 or 30 miles short of the extremity of the Cape, and proceed on horseback: though it is practicable to proceed with wheels. But for seven or eight miles before reaching Provincetown, he must find his way almost without a tract along the margin of a salt marsh during ebb tide. During flood tide, he will be forced to wade through the loose and deep sand higher up the beach. The view of Provincetown along this course, is so peculiar, that the traveller feels himself amply repaid for his labor. A semicircular bay is enclosed on the north and east by a sandy beach and low sand hills almost destitute of vegetation, which seem to threaten, and do in fact threaten, to bury the village, and to fill the harbor. The houses, for a population not much short of 2000, are erected on the margin of this bay, just above the reach of the tide, and at the foot of the sand hills. These dwellings are almost as destitute of order in their position, as it is possible they should be: such a thing as a regular street, wide enough for carriages to pass, being scarcely to be found here; and why indeed, should they be, where travelling in a carriage, would be slower than on foot, and where but very little fodder can be obtained, except by transportation, for horses. But the most singular object in this place, is the numerous windmills erected between the dwellings and the harbor, for pumping up the water into reservoirs for evaporation. When set in brisk motion by the wind, standing as they do between the traveller and the dwellings, as he comes from the south, they give to the village a most singular aspect. In short, a visit to Provincetown by land, would probably in most cases, be quite as effectual a remedy for ennui and other fashionable complaints, as a resort to Ballston and Saratoga.

In crossing the sands of the Cape, I noticed a singular mirage or deception, which was also observed by my travelling companions. In Orleans for instance, where the ocean is within a short distance on either hand, we seemed to be ascending at an angle of three or four degrees; nor was I convinced that such was not the case until turning about I perceived that a similar ascent appeared in the road just passed over. I shall not attempt to explain this optical deception: but merely remark, that it is probably of the same kind, as that observed by Humboldt, on the Pampas of Venezuela; 'all around us,' says he, 'the plains seemed to ascend towards the sky.'

In crossing the island of Nantucket, in company with Dr. Swift of that place, I noticed the same phenomenon, though there less striking. Afterwards, I saw it for miles on the plain in the south-eastern part of Martha's Vinyard. In the latter case, the plain was covered with low shrub oaks.

Nantucket and Martha's Vineyard.

If the traveller wishes to enjoy more of the peculiar scenery of Cape Cod, with some interesting variations, let him pass over to Nantucket and Martha's Vineyard. The former island he will find to be an extended plain, 15 miles in its longest direction, and but slightly elevated above the ocean; containing not one tree, nor a shrub of much size, except in the immediate vicinity of the village. Scarcely a dwelling will meet his eye, except a few uninhabited huts, scattered along the desolate shore, as a refuge to the shipwrecked sailor. Yet from 12000 to 14000 sheep, and 500 cows find nourishment on this island; and in not a few places, especially in the immediate vicinity of the town, may be seen tracts of land of superior fertility. It will strike the traveller at once, as an interesting monument of industry, that nearly every part of the dwellings, stores, &c., for the accommodation of more than 7000 inhabitants, must have been transported from the Continent. And on acquaintance, he will find that they still retain the characteristics of industry and hospitality, for which they have long been known; and that the usual concomitants of these virtues, general intelligence and strong local attachments, are not wanting.

Gay Head.

The most interesting spot on Martha's Vineyard is Gay Head; which constitutes the western extremity of this island, and consists of clays and sands of various colors. Its height cannot be more than 150 feet; yet its variegated aspect, and the richness of its colors, render it a striking and even splendid object, when seen from the ocean. The clays are red, blue and white; the sands, white and yellow; and the lignite, black; and each of these substances is abundant enough to be seen several miles distant, arranged in general in inclined strata; though from being unequally worn away, apparently mixed without much order. The top of the cliff is crowned by a light house, which commands an extensive prospect. Scarcely a tree is to be seen on this part of the island. It is owned and inhabited by the descendants of the Indian tribes, that once possessed the whole island. It will be seen in the subsequent part of my Report, that this spot possesses peculiar attractions for the geologist and mineralogist. During my last visit to the spot, three days were fully occupied in interesting researches.

WATER FALLS.

We have one or two water falls in Massachusetts of sufficient magnitude to be denominated cataracts. And as we might expect in a mountainous region, cascades are numerous.

Turner's Falls.

These exist in Connecticut river, near the point where the towns of Montague, Gill, and Greenfield, meet. They are by far the most interesting water fall in the State; and I think I may safely say in New England. At least, to my taste, the much broader sheet of water, the higher perpendicular descent, and the equally romantic scenery of the surrounding country, give to this cataract a much higher interest, than is excited by a view of the more celebrated Bellow's Falls on the same river, in Walpole, New Hampshire: and probably the latter are generally regarded as the most striking object of this kind in New England.

Above Turner's Falls the Connecticut for about three miles, pursues a course nearly northwest, through a region scarcely yet disturbed by cultivation; and all this distance it is as placid as a mountain lake, even to the verge of the cataract. Here an artificial dam has been erected more than a thousand feet long, resting near the centre upon two small islands. Over this dam the water leaps more than 30 feet perpendicularly; and for half a mile continues descending rapidly and foaming along its course. One hundred rods below the falls, the stream strikes directly against a lofty greenstone ridge, by which it is compelled to change its course towards the south at least a quarter of a circle.

The proper point for viewing Turner's Falls, is from the road leading to Greenfield on the north shore, perhaps 50 rods below the cataract. Here, from elevated ground, you have directly before you, the principal fall, intersected near the centre by two small rocky islands, which are crowned by trees and brushwood. The observer perceives at once that Niagara is before him in miniature. These islands may be reached by a canoe from above the falls in perfect safety. Fifty rods below the cataract, a third most romantic little island lifts its evergreen head, an image of peace aud security, in the midst of the agitated and foaming waters, swiftly gliding by. The placid aspect of the waters above the fall, calmly emerging from the moderately elevated and wooded hills at a distance, is finely contrasted with its foam and tumult below the cataract.

The country around these falls is but little cultivated. On the opposite side of the river the observer will, indeed, perceive a few dwellings and the head of a canal: But a little beyond, wooded elevations, chiefly covered with evergreens, terminate the landscape; while in every other direction, the scenery is still more wild and unreclaimed from a state of nature.

A sailing excursion from the falls, three miles up the stream, has all the attractions of a passage over a mountain lake, and probably the coves along the shore furnish as good spots for fishing as now exist in the river. The geologist too, will find the vicinity of these falls full of interest—but of this, more hereafter.

Three miles above Turner's Falls, Miller's river empties into the Connecticut; and near its mouth is a fall of considerable height. Here also is a dam across the Connecticut, about ten feet high. I apprehend these falls have been confounded with Turner's; and hence the latter are sometimes called Miller's Falls. They cannot, however, be said to have as yet any well established name. For a reason which will be mentioned below, I ventured some eight or ten years since, in a geological account which I published of the Connecticut valley, to denominate these falls, *Turner's Falls;* and Gen. Hoyt, in his History of the Indian Wars, has given them the same designation. I am aware, however, how very difficult it is to make popular and prevalent, a new name for any natural object; although in the present case, I doubt not, that every man acquainted with the history of this spot, would say that to prefix the name of Capt. Turner to this cataract, is appropriate and just.

About 160 years ago, a party of Philip's Indians, having joined those living in the vicinity, resorted to these falls to take fish. On the 17th of May, Capt. Turner, from Boston, marched from Hatfield, with 150 men, and came by surprise upon the Indian camp the next morning at day light. The Indians being totally unprepared for an attack, fled in every direction; some springing into their canoes without paddles, were precipitated over the falls and dashed in pieces. Three hundred Indians, and but one white man, were killed. Yet the Indians who escaped, being joined by others, fell upon Turner's party as they were returning, and made a dreadful slaughter among them; killing thirty seven, among whom was Capt. Turner. Will not the public do the justice to this brave but unfortunate officer, to send down his name to posterity, associated with that of the spot where he conquered and from fell!

During high water, the roar of Turner's Falls may be heard six to ten miles. The magnificence of the cataract is greatly heightened at such a season.

In order to visit Turner's Falls, one must turn aside from every great public road; and although but four miles from the village of Greenfield, this circumstance shows why they are so seldom resorted to by travellers. (See Plate IX.)

Falls at South Hadley.

The descent of the water here being but a few feet, these falls do not in themselves possess any great interest; and yet, as one of the objects in the beautiful landscape which has already been described as existing at this place, their absence would be sensibly felt by the man of taste. (Plate VI.)

Shelburne Falls.

These occur in Deerfield river where it enters the narrowest part of that deep ravine in the primary strata, betwen Shelburne and Conway, which has been already described. As a mere object of scenery they are not so striking as Turner's Falls; though they exhibit not a little of wildness and sublimity; and they are especially worth a visit from the geologist, as affording a good exhibition of the effects of a mountain torrent upon the hardest of rocks.

Spicket Falls.

Spicket river is a tributary of the Merrimack, and a few miles above its mouth in Methuen, it falls 30 feet. These falls are in the midst of a flourishing manufacturing village, and are a beautiful object, well worthy the attention and the pencil of the man of taste.

Falls in Fall River.

These are most interesting on account of the economical purposes to which the waters are applied: keeping in motion, as they do, all the machinery of a large and flourishing manufacturing village in Troy. Still, a stream of any size cannot fall 100 feet in the course of a few rods, without presenting natural scenery of some interest.

Pawtucket Falls.

These occur in the Merrimack, between Lowell and Dracut; and their romantic appearance is heightened by the bridge erected at their head.

The Gorge, Alias, the Glen.

In the south part of Leyden, a large brook has worn a passage from 10 to 20 feet wide, and from 30 to 50 feet deep, in the strata of argillo-micaceous slate. The layers of the slate are nearly perpendicular, and it is traversed by numerous cross seams, into which the water penetrates, and in winter freezes, expands, and thus assists in removing mass after mass of the rock from its place. A slight inspection of the place will show that such was the mode of its formation; although one cannot but perceive that a great length of time was requisite for the whole process. There is not the slightest appearance of any convulsion at this place, since the original elevation of the strata. The correspondence between the salient and reentering angles on opposite sides of this stream, is no greater than exists in every stream; and all the appearances at the place forbid the supposition often made that these sides have been separated from each other. The length of this gorge is from 30 to 40 rods. Above is a deep glen; and below, the stream passes through a deep ravine. Two water falls near the lower part of the gorge add much to the interest of this spot. And although the geological chronometer here exhibited, is to the reflecting mind, its greatest attraction; yet the wildness and ruggedness of the scenery draw not a few visitors. The term 'glen,' usually applied to this spot, is certainly a misnomer. For it is a gorge connecting a glen with a ravine.

Cascade in Leverett.

I have recently ascertained the existence of an interesting water fall on the northeast side of Mount Toby, in Leverett. The conglomerate rock of that mountain has been subject to powerful abrasion in early times; and being divisible into masses of great thickness, by fissures nearly perpendicular to the horizon, the sides of the mountain frequently present perpendicular walls of solid rock, and sometimes a succession of precipices in the form of vast steps; while the huge fragments that have fallen down, lie scattered along the base. Such is the case at the spot above referred to; where a large brook, called 'roaring brook,' comes tumbling down by a few successive leaps from the height of 200 or 300 feet. The waters have worn deep chasms in the rocks, and the scenery around is of the wildest and most romantic character. Every thing there —the lofty forests—the overhanging precipices—and the accumulated rocky masses below—remain unmodified by the hand of man just as the mighty agencies of nature have left them.

Cascade, Natural Bridge, and Fissure, on Hudson's Brook.

The present falls on this rivulet, which run through the north part of Adams, are of far less interest than the deep chasm which its waters have excavated in the white limestone. This limestone terminates on the south in a high precipice, over which the stream once fell. But it has worn a fissure from 30 to 60 feet deep, and 30 rods long, in this limestone, and left two masses of rock connecting the sides and forming natural bridges; though the upper one is much broken. The lower one is arched, and the stream at present runs 50 feet below it. The medium width of the stream is 15 feet.

Canaan Falls.

These are just within the boundaries of Connecticut, on the Housatonic. The water takes two leaps within a short distance; the upper one of 20 feet, and the lower one of 70. It then foams and dashes a short distance and takes a third leap of about ten feet. The effect of the whole scene is imposing.

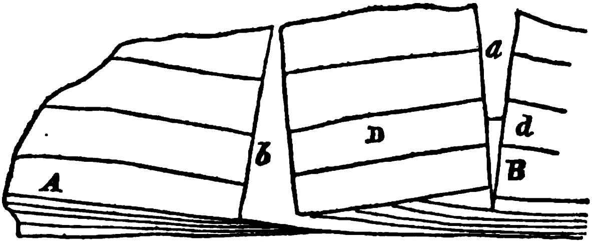
CAVERNS AND FISSURES.

Southampton Adit.

I have alluded in the first part of my Report, to this artificial excavation, 900 feet in length, at the lead mine in Southampton. It is a perforation mostly in solid rock, large enough to admit a boat with several persons; and in this manner might be entered with perfect safety. Being unique in this part of the country, it had become a place of considerable resort by gentlemen and ladies during the summer months. At present the entrance is blocked up; but it is to be hoped that ere long the working of this adit will be resumed, and an opportunity again afforded for so fine a subterranean excursion.

Sunderland Cave, and Fissure.

The following section will, I apprehend, render intelligible, not merely the form and situation of this cave and fissure, but also the mode of their production. They occur in a conglomerate rock of the new red sandstone, on the northwest side of Mount Toby, in the north part of Sunderland. The conglomerate strata are several feet thick; and immediately beneath this rock lies a slaty micaceous sandstone, which is very subject to disintegration; as may be seen a little north of the cave, where the conglomerate projects several feet beyond the slate, whose ruins are scattered around. The spot is perhaps 300 or 400 feet above Connecticut river: yet there is the most conclusive proof in all the region around, that water once acted powerfully, and probably for a long period, at various elevations on the sides of this mountain: and not improbably this aqueous agency assisted in undermining the conglomerate rock by wearing away the sandstone.



At *A*, and *B*, the rock is but slightly removed from it original position; but in the space between these points, the slate appears to have been worn away so as to cause the whole conglomerate stratum, which is from 50 to 60 feet thick, and consequently of immense weight, to fall down, producing the fissure *a*, and the cavern *b*. The fissure is nine feet wide at the top, and open to *d*, 40 feet; below which it is filled with rubbish. The cavern is wider than this in some parts, though very irregular in this respect. Its bottom also is rendered quite uneven by the large masses of rock that have tumbled down. In the deepest spot, (56 feet) the rocks are separated to the surface, so as to let in the light from above. The whole length of the cavern is 148 feet. Its general direction is nearly east and west. But towards its eastern part it turns almost at right angles to the left, in consequence of the rock *a*, having been broken in a north and south direction from the mass of the mountain.

Some who visit this spot are disposed to call in the aid of a convulsion like an earthquake to explain the huge fractures there exhibited. But after seeing so many other marks of the powerful action of atmospheric and aqueous agents on this mountain, I cannot but believe the cause I have assigned to be sufficient. The place is well worth visiting by all who have not examined other caverns and fissures extensively.

On the opposite side of Mount Toby, a little south of the cascade that has been described, one or two other caves occur, more irregular but less extensive than this. They have been produced by the enormous masses of the mountain that have been here mixed *pellmell* together.

Caverns in Berkshire.

These all occur in limestone; and are so similar, that it is hardly necessary to describe them separately. Two exist in the south part of New Marlborough, containing several apartments and some stalactites. In West Stockbridge is a small one. In Lanesborough is one 100 feet long, narrow and irregular, produced probably by a subterranean stream. In Adams, a mile south of the north village, on the Cheshire road, is a cavern of considerable interest; containing several apartments; the largest of which is 30 feet long, 20 feet wide, and 20 feet high. A similar cave may be seen in Bennington, Vt. And although these caverns will not compare in extent with those in our western states, yet they will afford not a little gratification, to those not familiar with subterranean excursions.

Purgatories.

I know not what fancied resemblances have applied this whimsical name to several extensive fissures in the rocks of New England. The most remarkable case of this kind is in Sutton, three and a half miles south east of the congregational meeting house. It is a fissure in gneiss, nearly half a mile long, in most parts partially filled by the masses of rock that have been detached from the walls. The sides are often perpendicular, and sometimes 70 feet high; being separated from each other about 50 feet.

This is an immense chasm: and I confess myself at a loss to explain its origin. It is natural to suppose that its sides have been in some manner separated from one another.. But I can conceive of no mode in which this could have been accomplished, but by a force acting beneath: and this would so elevate the strata, that they would dip on both sides *from* the fissure. But I could discover no such dip. The inclination along the fissure corresponds with that which is common in the region around; viz. about 25° N. E. In the vicinity of the fissure, however, the rocks are often exceedingly broken into fragments:* and this circumstance indicates some early subterranean convulsion. Still, I am rather inclined to refer these fragments as well as the fissure, to the long continued action of the waves of the sea, when the spot was so situated as to form a shore of moderate elevation. The next case of a purgatory which I shall describe, will illustrate the mode in which the waves might have produced such effects.

In Newport, Rhode Island.

In the southeast part of this town (perhaps it is within the limits of Middleton,) the coarse conglomerate rock contains numerous cross seams, which are parallel to one another, and nearly perpendicular to the horizon. In one spot, in a high rocky bluff, two of these fissures occur not more than six or eight feet asunder; and the waves have succeeded in the course of ages, in wearing away the intervening rock, so as to form a chasm about seven rods in length, and 60 or 70 feet deep; the sides being almost exactly perpendicular. This chasm is called Purgatory; and the waves still continue their slow but certain work of destruction.

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* Visitors of the Sutton Purgatory should recollect that such broken rocks furnish a fine retreat for the Rattlesnake. I met with one among the *debris* of that place. But as he kindly warned me that I was trespassing on his territory, I thought it ungenerous to attack him, and we parted on good terms, mutually willing to be rid of each other's company.

On the south shore of Newport, a similar fissure occurs in granite. It is, however, much less extensive, not more than twenty feet deep perhaps: and the waves sometimes rush into it with such violence that they are dashed not less than thirty feet into the air. Even granite yields under this everlasting concussion. This spot is called the Spouting Cave.

We have only to suppose the Sutton Purgatory to have been once similarly situated in respect to the ocean, and we have a cause adequate to its production. And yet, what an immense period must the whole work have demanded!

Autumnal Scenery.

Perhaps no country in the world exhibits in its autumnal scenery, so rich a variety of colors in the foliage of trees, as our own. But it is particularly beautiful in the more mountainous parts of the land. The trees, whose leaves give the liveliest tints, are the maple, the oak, the walnut, and the sumach; while the pine and hemlock retain their deep green: and if these species be fantastically mixed on a mountain's side, they present a splendid drapery, which, though somewhat approaching to the gaudy, is yet extremely interesting. The change generally commences as early as the middle of September, and does not attain its full perfection till after several frosts of considerable severity. The change proceeds undoubtedly from an increased oxygenation of the coloring matter of the leaves; analogous changes being easily produced in the chemical laboratory by the addition of oxygen to certain compounds,* as for example, the *Chameleon Mineral.* This process in the eyes of a chemist does not seem, as I believe it does to most men, a condition of sickness connected with the decay and fall of the leaf. He views it rather as a beautiful illustration of the means which nature possesses to produce variety. True, it is one of the more advanced steps of vegetable life; but does not seem to be disease. Or if any are disposed to consider it such, it ought to be looked upon as nature descending joyfully in her richest dress into her wintery grave, in exulting anticipation of a speedy resurrection.

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* Annales de Chimie et de Physique, Vol. 38, p. 415.

Although this phenomenon forms an attractive object to the geologist in his wildest excursions among the mountains, at the most delightful season in the whole year for geological research, yet it cannot be regarded as having any connection with geology. But not being aware that any attempt has been made to preserve these autumnal colors on canvas, I have taken the liberty to attempt such a landscape, and herewith transmit it to your Excellency. As it was necessary to watch with great care the proper time for seeing these colors when in their greatest perfection, I have selected a view of the village in which I reside; and if I mistake not it presents a tolerably good specimen of this kind of landscape.

Sketches of Scenery Accompanying this Report.

It has been in my power to obtain sketches of some of the most striking scenery which has been described in this part of my Report: and I take the liberty to forward the same for your inspection. I am indebted for them to Mrs. Hitchcock; as I am for nearly all the drawings and maps accompanying every part of this Report. The landscapes are chiefly confined to the Connecticut Valley; it not having been convenient for her to accompany me to distant parts of the State. They are the following.

1. *Autumnal Scenery.* A view in Amherst. (Plate II.)
2. *A view in Hadley.* This was taken from the south end of east street in Hadley; standing on the banks of Connecticut river, and looking southerly down the stream and through the gorge between Holyoke and Tom. (Plate III.)
3. *A view from the south through the gorge between Holyoke and Tom.* This was taken from a high bank on the east side of the river, about a mile below the gorge. In looking through the gorge, Connecticut river is seen making several extensive windings through Northampton meadows, while at a distance, a most delightful view of the village of Northampton and the Round Hill School is obtained. (Plate IV.)
4. *View from Mount Holyoke.* This is a westerly view in the direction of Northampton. It was taken about half way from the base to the summit of the mountain. But it does not differ essentially from the view at the summit. It is perhaps the most delightful prospect in New England; yet its character is such that it must appear to great disadvantage upon a drawing. The central parts of this landscape are considerably contracted, in order to bring into view the whole of the remarkable curve in the Connecticut on the right. (Plate V.)

5. *View of South Hadley Falls.* The falls are in themselves an object of little interest in this landscape. But the beautiful village at their foot, the wooded amphitheatre in its rear, and Mount Tom, towering in the back ground, with other objects of interest, conspire to render this a very striking view. (Plate VI.)

6. *View of Sugar Loaf Mountain.* This sketch was taken from the plain about a mile south of the base of this conical elevation. On the right we look up the valley through which the Connecticut runs; and on the left, appears what is called North Sugar Loaf: it being the southern precipitous termination of the sandstone ridge that runs through Deerfield, &c. Both elevations, in order to exhibit a natural appearance, should be colored of a reddish hue towards their summit. (Plate VII.)

7. *View at the Confluence of Deerfield and Connecticut Rivers.* This was taken from an eminence about one mile east of the bridge across Deerfield river' between Deerfield and Greenfield, and near the residence of Col. John Wilson. That bridge, seen through a gorge in a greenstone ridge, appears on the left in the drawing; beyond which, Deerfield meadows open: and in the distance, rise the primitive ridges of Shelburne, &c. Deerfield river flows towards the right hand side of the sketch, where it mingles with the Connecticut that comes in from the north. The bridge seen on the right in the drawing, is on the Connecticut, a little above its junction with the Deerfield. After uniting, these streams pass southeasterly, as may be partially seen on the right hand side of the sketch. The bridge across the Connecticut, connects Montague on the east shore with Greenfield on the west. Above the bridge, may be seen an island; and still farther north, the river washes the eastern base of a greenstone ridge, which, in the central parts of the drawing, is covered with woods. These central parts are more contracted than a just proportion would allow, in order to bring both rivers upon the same sketch. (Plate VIII.)

8. *View of Turner's Falls.* This view was taken from the place on the north or Gill shore, already described as the best point for viewing the cataract. Near the small buildings on the right, is the spot where occurred the bloody battle between Capt. Turner and the Indians of which I have given an account. On the eminence a little beyond, was an Indian fort. (Plate IX.)

9. *Sketch of the Gorge or 'Glen' in Leyden.* In this view the observer looks northerly through one of the wildest portions of the ragged chasm; having before him at least two interesting cascades. (Plate X.)

Here I close the second part of my Report. It has increased under my pen beyond my expectations. But I could hardly have said less consistently with giving any thing like a correct view of our scenery. If what I have said should lead others to visit and enjoy, as I have done, the spots that have been described, I am sure I shall be the means of imparting much happiness, and shall feel a confidence that I have not written in vain.

Respectfully Submitted,
EDWARD HITCHCOCK.

Amherst College, June 1, 1833.

SCIENTIFIC GEOLOGY.

PART III.

To His Excellency Levi Lincoln, Esq.
Governor of Massachusetts.

According to the plan suggested in the first part of my Report, I now proceed to the consideration of the Scientific Geology of Massachusetts.

Having already given a view, professedly popular, of our rocks and minerals which are interesting in a pecuniary respect, I shall make no apology for entering into full details in this third part of my Report, of all the geological phenomena in the State, that have fallen under my notice, and seem of any importance to the science. I shall endeavor, however, to avoid all unnecessary prolixity.

No science is making such rapid progress as geology. Even since I received your Excellency's Commission, three years ago, several important principles have been developed by able geologists, which I shall apply to the rocks of this region, so far as I am able. In Europe geological researches have been pushed much farther than in other quarters of the globe; and it is an interesting inquiry, how far the phenomena of rocks in other regions correspond with those in Europe. I hope to show that the rocks of Massachusetts exhibit some analogies of this kind, that prove an identity of the causes that produced them.

The technical terms which I shall be under the necessity of employing, will be used, so far as I understand them, in the sense adopted by the most recent and approved authors. Geology, however, does not abound in terms of this kind; nor shall I employ more than necessity requires.

I ought perhaps to remark that the term *rock*, will be sometimes employed, as it is by most geological writers, to include the loose materials and soils embraced in the alluvial, diluvial, and tertiary formations, as well as those solid masses, to which the term is limited in its popular sense.

It is well known that there is not a little diversity among the ablest writers in respect to the names of rocks. Under such circumstances an infallible nomenclature is out of the question. But if, as I intend to do, I describe definitely what is included under each name attached tq the accompanying geological map, it seems to me that the difficulty will be in a great measure obviated: especially as I shall present specimens to the Government, of every variety of rock that is described. And should they take measures for preserving this collection, future geologists may know precisely what is comprehended und ereach rock mentioned in this Report.

Geologists are not agreed whether it is best to describe rocks in a descending or an ascending order; that is, whether they shall commence at the surface with the most recent rocks, or with the lowest hitherto discovered. Each plan has some advantages and some disadvantages peculiar to itself. Without stopping to assign the particular reasons, I shall choose a descending order; that is, I shall commence with the uppermost stratum: and in adopting this course, I follow the example of most of the ablest geological writers of the day, such as Brongniart, De la Beche, Lyell, Mantell, &c.

As to the Classification of Rocks, there is also very much diversity among the ablest writers; although there has been great improvement in this respect within the last 15 or 20 years. Yet, excepting a few general principles, the different systems for the arrangement of rocks must be regarded as provisional merely, awaiting the revision of some future Linnæus in Geology. Among the principles which I regard as established in the science, one is the division of rocks into stratified and unstratified. This division, therefore, I shall adopt. But instead of stopping here to explain the subdivisions of these classes, I shall introduce a Tabular View of the rocks in Massachusetts, arranged as nearly as possible in the order of their superposition; and opposite their names, I shall put down the most important and ingenious systems of arrangement now in use among geologists; so that a comparative view of them may at once be obtained. (See the accompanying Atlas, Plate XIX.) The first column contains the names of the rocks under which I describe them; the second column, the varieties of each rock observed in Massachusetts; the third column, a catalogue of minerals found imbedded in each rock; and the remaining columns, the various systems above referred to. The simple minerals are put down without any attempt at classification; it being thought sufficient to refer them to the rocks in which they are found.

In describing the various rocks in the State, I shall, as far as possible, follow a uniform order, giving first the mineralogical characters; next the topography of the formation; next the dip, direction, &c. of the strata; next an account of the organic remains; next of the mineral contents; and finally, add some theoretical considerations. In many instances, however, this order cannot be observed; and in others, some of the above particulars will need no notice.

I was in doubt for a time whether it would be advisable to add any remarks upon the theory of the rock formations, or the explanation of particular phenomena. But such an addition seemed wanting to complete my account of the rocks; and I came to the conclusion to attempt an explanation of all the most important phenomena, which I describe. There will of course be a diversity of opinion concerning many of the theories, and especially concerning the hypotheses, which I shall advance. I have given those which are most satisfactory to my own mind, after consulting several of the most recent, and most able writers upon geological philosophy. While I could not but express plainly, my own decided convictions, I hope I have not done it dogmatically.

A few words more may be necessary in explanation of the Geological Map. I have striven to reduce it to such simplicity, that its plan and arrangement will be obvious by mere inspection. Some things about it, however, may need elucidation. To avoid confusion and mistake, I have employed but six colors; which, with the exception perhaps of the blue, are so strongly marked, that they can readily be distinguished by candle light. These colors mark off the rocks of the State into what may be regarded as distinct groups: the members of each group, with the exception of the fourth, being so nearly related, that they might even be regarded, in most cases, as belonging to the same formation; or if this term be too limited in its meaning, we might resort to the *terrain* of the French geologists; a word to which we have no one in English exactly corresponding. The first group, however, embracing all the unstratified rocks, would include more than one *terrain,* if that term can embrace only the rocks produced during one geological epoch, or period.* The second group embraces only gneiss, and those rocks which are so intimately associated with it, that they constitute but a single formation. The third group comprehends mica slate and those rocks that are so closely connected with it, as to show great similarity in the causes that produced them; although perhaps not all of them were formed during the same epoch. The fourth group is miscellaneous, including rocks that have no necessary connection or resemblance. The fifth group includes all the consolidated rocks resulting from sediment; although obviously belonging to at least three distinct formations. The sixth group, takes in all the unconsolidated beds above the chalk, or its equivalent in this country, the ferruginous sand formation.

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* See Brongniart's 'Tableau des Terrains,' &c. p. 4. Introduction.

The tablets attached to the Map will show the particular marks by which the members of the different groups are distinguished from one another: And to afford still farther means for accomplishing the same object, and preventing mistakes, I have placed a figure on each tablet, which corresponds with the same figure placed upon the map in every place occupied by that particular rock; so that even if in any case the painter has applied a wrong color, these figures will afford the means of detecting the mistake.

STRATIFIED ROCKS.

The uppermost portion of this division of the crust of the globe consists for the most part of unconsolidated layers of sand, clay, and gravel. The lower portion embraces all those solid rocks that are divided by parallel and continuous seams. The stratified rocks occupy in every country by far the largest proportion of the surface.

ALLUVIUM.

It is well known that a number of causes are daily operating to modify the surface of the globe. In some instances new and solid rocks are gradually forming; in others, and those far the most numerous cases, the rock strata are wearing away, and the fragments, carried by water to the lowest spots, are deposited in the form of sand, gravel, clay, and loam. But all such deposits, whether consolidated or not, are denominated alluvium; excepting only the products of volcanoes.

Alluvium of Rivers.

The deposits produced by the overflowing of rivers, are the most common and familiar example of this stratum. They will, of course, consist of that heterogenous mixture which a swollen and agitated stream sweeps along. When first the river issues from the mountains and begins to spread over the plains, coarse gravel and sand, and not unfrequently large bowlders, will be deposited. The finer materials, and most of the vegetable and animal substances, being lighter, will float on farther before subsiding.

So that the portion of an alluvial tract which is nearest the mouth of the stream, will generally be most valuable in an agricultural point of view, being made up of the finest and richest loam.

It is quite obvious that the power of rivers in depositing alluvium must be lessened by every successive innundation ; since the more elevated the banks, the less frequently will the stream rise above them ; and the less the amount of water thrown over the meadows. In some places, along the Connecticut and its tributaries, the banks have already attained such an elevation, that it is only at long intervals that the floods are high enough to surmount them ; and yet they are obviously the result of alluvial deposition.

The Connecticut and its tributaries, the Deerfield and the Westfield, furnish the only examples of river alluvium of much extent and importance in the State. Some fine meadows of this description, however, occur on the Housatonic, in Stockbridge, Great Barrington and Sheffield. Indeed, every river in the State, and every brook, present limited tracts of this stratum. But only those along the Connecticut and Housatonic were thought deserving of a place on the Map. In some instances the deposition of the Connecticut, the Deerfield, and the Westfield, is 15 or 20 feet thick. Logs, leaves, walnuts, butternuts &c. are frequently imbedded at that depth, and but slightly changed. Relics of this kind, though of but little importance to the geologists of the present age, may be viewed with great interest in future times, when this alluvium shall have become consolidated and other formations shall be imposed upon it.

The alluvial basin of Deerfield river, in Deerfield, is perhaps the most remarkable example of this formation in the State. It is shut in on all sides by high land, and the river is obliged to force its way to the Connecticut through a narrow gorge in a high ridge of greenstone ; and its direction where it empties, is almost opposite to the course of the Connecticut. The Deerfield, being a mountain torrent, and of less extent, is raised several hours earlier than the Connecticut after a rain. It even begins to subside before the latter has risen much. But as the Connecticut swells, it throws back the waters of the Deerfield over the broad basin among the mountains, and sometimes retains it there for three or four days, or even a week, until the very finest sediment is deposited. The consequence is, a rapid growth of alluvium, and great fertility of soil.

It is interesting to observe in Deerfield Meadows the numerous changes in the bed of the river, that have taken place at no very remote period ; though none of much importance since the settlement of the place by the whites. A map of these changes might be instructive as illustrating the operation of existing geological agencies. But I did not judge it expedient to construct one, since so many other cases of more importance will require drawings. I remark, however, that as the banks of this river are easily worn away, constant changes are taking place with much rapidity by the action of the stream, so that it must be a fine place for studying fluviatile dynamics.

Patches of river alluvium are represented on the Map in Stockbridge, Sheffield, Great Barrington, Longmeadow, Springfield, West Springfield, Northampton, Hadley, Hatfield, Whately, Deerfield, and Northfield.

Coast Alluvium.

This sort of deposition is of two kinds. The first is produced by tides and currents in the ocean, which frequently transport large quantities of soil from one place to another, and cause it to accumulate in those situations where their force abates, or is destroyed. In the southeastern part of the State, such cases are numerous: and I have regarded the sandy accumulations of this kind in Provincetown; opposite Chatham and Harwich; on the north shore of Barnstable; and in several places along the northwest coast of Nantucket, as of sufficient extent to deserve a notice upon the Map. Deposits of this kind on a smaller scale are very common in the southeast part of the State.

Salt Marsh Alluvium.

Salt marsh alluvium results from the joint action of two, and sometimes three causes: 1. from the decay of salt marsh plants; 2. from the silt brought over the marsh by the tides; and 3. from the alluvial soil brought down by streams, when these happen to empty through those marshes. The marshes in the vicinity of Boston consist chiefly of a clayey loam, with vegetables more or less decayed, forming in fact an imperfect deposit of peat. The depth of the peculiar pulpy soil of these marshes is rarely more than 6 or 8 feet. In the southeastern part of the State, the salt marshes are much more sandy. In fact their character depends very much upon the nature of the soil on the coast, since this is carried by the sea into the marshes and deposited. Though salt marshes are numerous along the coast, this kind of alluvium is marked on the map in only two places, viz. in Charlestown and Chelsea.

Submarine Forests.

Though these have not hitherto been noticed in this country, I am inclined to believe that they are not uncommon in the southeast part of the State, and probably all along the Atlantic coast.

They consist of the remains of ancient forests, now submerged a few feet below the sea, though sometimes laid bare at low water. The vegetables found in them are generally such as grow in low land; and, indeed, peat not unfrequently occurs. This is the case in the harbor of Nantucket, as I am informed by Lt. Jonathan Prescott, of the U. States army. This gentleman, while superintending the dredging of that harbor, found portions of cedar, maple, oak, and beach trees, some of them in an erect position and accompanied by peat of an imperfect character. All the wood, except the cedar, (*Cupressus thuyoides,*) which was nearly as sound as ever, was very much decayed. These relics were buried by four feet of sand, and were about eight feet below low water mark.

Another submarine forest exists at Holme's Hole, on Martha's Vineyard. It is on the west side of the harbor, and was described by the pilot as having the appearance of a marsh at low water. Stumps have been found there in considerable quantity; of the cedar at least.

Near the southwest extremity of the Vineyard, on the north shore, I was informed that another forest of a similar description may be seen. On the north side of Cape Cod, also, opposite Yarmouth, cedar stumps may be found (as I was informed by the Captain of the Falmouth packet,) extending more than three miles into Barnstable Bay. And Mr. Henry Wilder, of Lancaster, who first directed my attention to this subject, says that the same thing occurs in the bay of Provincetown, on the side opposite the village. Farther inquiries will no doubt bring to light many more instances of a similar character: for my opportunities of observation on this subject have been but few.

Geologists are not a little perplexed, satisfactorily to account for submarine forests. Some of them, it has been thought, might have resulted from the breaking of the barrier of a peat swamp by the ocean; whereby it was drained and the soil rendered more compact so as to subside below the level of the ocean. But in general it has been supposed that these forests have subsided in consequence of earthquakes or other internal movements of the earth. But if it should be found, as there seems reason for believing, that they exist in every quarter of the globe, and at nearly the same depth beneath the ocean, a cause (like those just named) which is local and irregular in its operation, will hardly explain their occurrence.

Peat.

Various causes are in operation to produce an accumulation of mud upon the bottoms of ponds, lakes, estuaries, &c. In this mud various aquatic plants will take root, and by their decay will swell the deposite. At length the pulpy mass nearly reaches the surface when sphagneous and other mosses take root in it, along with numerous other plants, and by their gradual decomposition, the pond or the lake becomes converted, in the course of ages, into a swamp or marsh. On digging into it, the bottom will be found to consist, near the surface, of interlaced vegetable fibres and roots, with only a small proportion of earth; farther down the vegetable matter will be found more decayed and compact, until at length, in many instances, perfect compact peat, with occasional layers of mud, will be discovered.

This is the simple and summary account of the origin of the different varieties of peat. And since the process is daily progressing, it is properly an alluvial formation: though probably a part of the peat in this State was produced previous to some of the latest general and important changes which the earth has undergone. According to this statement, almost any vegetable matters, that have remained for some time beneath the surface of the soil, may be called peat; and it may even be produced beneath the sea by marine plants, such as the *Zostera marina.* It is only within certain limits of moisture and temperature, however, that proper peat can be produced: and hence in the torrid zone, the decomposition is so rapid and perfect, that peat is rarely found. Hence, too, in northern latitudes, the most elevated swamps are the most favorable spots for its production: that is, for abstracting the oxygen and hydrogen of the vegetable and leaving the carbon to predominate.

Numerous as are the deposits of peat in Massachusetts, very little need be said concerning it. The localities where it has been found most abundant, are noticed on the Map; though doubtless many others would be found equally prolific, if sought after. All the varieties noticed by authors—the marsh—the lake—the forest—the maritime and the transported peat—are found here. Indeed, according to the definition that has been given of this substance, it is perfectly obvious that not a town in the State can be named where more or less of it does not exist. The eastern section, however, is certainly best stored with those varieties that may be employed for fuel. And it is an unexpected fact, that the southeastern parts of the State, which abound with sand, contain also a large amount of peat. According to a survey by Lt. Prescott, the island of Nantucket and the small adjacent islands of Thuckanuck, Muskegut, and Gravel, contain 30,590 acres; of which,.1050 are fresh ponds, and 650 are peat swamps: the beds being from 1 to 14 feet thick, and generally of good quality. This must afford an inexhaustible supply of fuel for the inhabitants;

and yet I was surprised to learn, that although the price of fuel is very high there, peat is not much employed. This perhaps results from the habit of bringing almost every article used on the island from abroad; or more probably from the general thrift and comfortable circumstances of the inhabitants, which enable them to employ the kind of fuel that is most pleasant; and who is there that would not prefer wood to peat.

The process by which peat is produced, must be every year less prolific in its results; especially in this country. For many swamps are already so much filled as to raise the plants on their surface too high to receive the requisite moisture. And besides, the trees and shrubs are cleared away from many, and their surfaces converted into fields for producing grass. Some very fine mowing lots of this description may be seen a little west of the village in Nantucket: and over the whole surface of that island, scarcely a tree or shrub is now to be seen, so that here the formation of peat has probably in a good measure ceased. The peat swamps there (as they now are in many parts of the southeastern extremity of the State) were probably once covered with the white cedar.

According to the Messrs. Danas, trunks of trees, generally of some species of pine, occur in peat, several feet below the surface in the marshes of Charles river.

Marl.

In limestone regions, the waters generally contain more or less of the carbonate of lime in solution; and this, gradually depositing along with the fine clay or mud held in suspension, produces one of the varieties of marl. In a few places in Berkshire County, such marl is now in the course of formation at the bottom of ponds. In this marl (Nos. 12 to 16,) we find Planorbis parvus, bicarinatus, and trivolvis, Lymnæa heterostropha and catascopium, with a nondescript species of Cyclas; all of which, except the last perhaps, correspond with existing species in the same region.

Alluvium of Disintegration.

Very few rocks have the power of completely resisting the united influence of air, water, heat, and cold. And some kinds are powerfully and deeply acted upon by these agents. Perhaps the new red sandstone is more affected in this manner than any other rock in Massachusetts: and not unfrequently its surface for several feet in depth, is converted into mere sand and gravel. This becomes gradually mixed with the soil, and gives a decidedly red hue to extensive tracts. Next to this sandstone—and I am not sure but even more subject to decay—is our gneiss; especially that in Worcester county. Hence in that part of the State—hilly as it is—we sometimes scarcely see a rock in place in crossing a whole township. In an excavation which I lately noticed in Spencer, I had an opportunity of observing that a disintegration had taken place in the gneiss, from 6 to 10 feet in depth. I could distinguish the materials resulting from disintegration, from the diluvium lying above them, by observing that in the former the masses of gneiss, remaining undecayed, had a position parallel to that of the layers of the solid gneiss beneath, being considerably inclined; whereas the fragments in the diluvium exhibited no such parallelism. I have never seen a disintegration so deep as this in the new red sandstone, though in the vicinity of New Haven, Ct. its depth is several feet. Some varieties of trap rock, particularly one on Connecticut river, whose base is wacke-like; and some of the sienites in the eastern part of the State that abound in iron, disintegrate, and even decompose, rapidly. Mica slate and talcose slate are similarly affected, though to a less extent, as is also argillaceous slate, and some varieties of slaty graywacke.

Quartz rock, for the most part, is one of the most indestructible of all our rocks. Those rounded and smooth bowlders of granular quartz especially, that are so common in the western part of the State among the diluvium, appear in general to have bid defiance to all decomposing agencies in past ages, and to be destined to endure unchanged for ages to come. Yet I had recently pointed out to me a rather curious, and somewhat instructive example of these bowlders, lying in the extensive fruit-tree nursery of Mr. Tracy, in Norwich. It was several feet in diameter, and though not as smooth as some bowlders of this kind, yet I should not have suspected that it had suffered the least waste, were it not for an inscription that appears upon it. The name of John Gilpin is marked on its upper surface, in a large fair hand, a few of the letters only being indistinct. These letters are not cut in the stone, nor do they consist of any foreign substance, like ink, or paint, spread over it. But they are rendered visible simply by the lighter color of the surface, where they were originally written; and by passing the finger over them, it is obvious that they project slightly. Hence I infer that these letters were originally written with some kind of paint, which prevented the rock beneath it from decaying; while the decomposing process went on gradually on the other parts of the stone. Now as these letters must have been written since the settlement of that part of the country, we cannot suppose that more than 150 years at the longest have since elapsed: and probably the period is much less. We have here, then, a sort of measure for determining the rate at which hard quartz rock will decay by atmospherical agencies.

Alluvium of Degradation.

Three causes are constantly operating to degrade the mountains and hills, and to fill up the valleys, viz: rains, frost, and gravity. That they have not already reduced the earth's surface to a level, is decisive proof that the globe has not existed in its present state eternally. Such a result must ultimately proceed from these causes, if they continue long enough in operation: and that would be to reduce the globe to an uninhabitable chaos: for if the present dry land were spread uniformly over the whole globe, the ocean would flow over the whole of it, even with considerable depth of waters.

In precipitous ridges, particularly of trap formation, frost commences the work of degradation. Water, penetrating the fissures of these rocks, expands by freezing and forces them slightly asunder. This makes room for a larger portion of water the succeeding winter; and thus the process goes on until the columnar masses of rock are urged downward by the force of gravity and powerful rains. This is the origin of those extensive slopes of broken fragments, or *debris* of rocks, which arrest the attention on the mural faces of the greenstone ridges in the Connecticut valley. Generally these fragments rise only about one half or two thirds the height of the ridge; though sometimes they continue to the very summit: the process of degradation from this cause having come to an end.

Instances of this kind have been regarded by geologists as a kind of natural chronometer, demonstrating the recent origin of the present state of the globe. No observations, however, have been made on the progress of this leveling process accurate enough to compare it with historical records.

When the three causes of degradation above mentioned combine their maximum energy on the sides of steep Alpine summits, they produce the well known and sometimes terrific phenomenon of *land-slips*. Though examples of these on a limited scale are very common in Massachusetts, yet the only one worthy the particular attention of geologists, is on the southwest side of Saddle Mountain, at the place called the Hopper. But this has been particularly noticed in the second part of my Report.

Bog Ore.

In the western part of Worcester county, and over a large extent of territory, the process by which this ore is produced and deposited, is so manifest that it deserves description. The gneiss rock there, abounds with the sulphuret of iron. This is continually undergoing a decomposition by the action of heat, air, and moisture; and becomes changed, first into an oxide, and then, some of it into a sulphate. The oxide usually imbibes more or less of carbonic acid from the atmosphere, and is changed into a carbonate; which is soluble in water. Or this oxide, being washed from the rocks by rain into cavities, meets with water containing carbonic acid, by which it is dissolved. Once dissolved, it is readily transported to ponds and swamps, and there deposited by the evaporation of the water. In the region above referred to, this process may be witnessed in all its stages. By breaking the rock we find the sulphuret unchanged; while the surface is coated over with the oxide, sulphate, and carbonate. The soil, also, to a considerable depth, exhibits very strikingly the color of iron rust; and in the low grounds the bog ore is abundant.

Probably a similar theory will apply to the production of this ore in other parts of the State; though I know of no spot where the process is so obvious as in Worcester county. Indeed, the fact that very many of our bog ore deposites are buried several feet deep by soil, and occur on dry ground, shows that in those places the process of its formation has long since ceased. In several ponds in the southeast part of the State, it is said, however, that it is forming rapidly.

Since iron is a mineralizer of organic substances, we might expect to find organic remains in bog ore. In that of Massachusetts, I have noticed only vegetable relics. In New Braintree the culms, spikes, and spikelets of grasses—mostly of carex—are common. The spikes and spikelets especially, are very distinct and perfect. (No. 19.) Even the natural color of the fruit is sometimes preserved; and to appearance it seems to be unaltered; but examination shows the whole to be only iron ore.

Oxide of Manganese.

I know not why geologists have omitted this substance in enumerating alluvial deposites. For it seems to have as good claims to be regarded alluvial, as bog ore and peat. I refer particularly to the hydrated oxide, or black wad; which is ordinarily a mixture of manganese, iron, and clay. This is certainly produced daily by a process analogous to that which forms bog ore; that is, the decomposition of rocks containing manganese, exposes that metal to be washed by water into cavities on the surface of the earth, where it either incrusts other substances, or forms a separate deposite. Instances of this incrustation may be seen every where in the primary region west of Connecticut river; and examples of such deposition I have observed in Leverett, Whately, and Conway. These deposites are sometimes a foot in thickness, and occur in low places, covered only by a few inches of soil.

Power of Ice in the removal of Bowlders in Ponds.

I am not aware that this phenomenon has been noticed on the eastern continent; and it has been but rarely observed on our own. Its effects in modifying the face of the globe must be very limited; yet they deserve enumeration.

It is well known that water, by an apparent exception to a general law, expands with great force when freezing, and even far below the freezing point. Over a large extent of surface this effect may be very considerable; and when bowlder stones, lying in shallow ponds, become partially enveloped in the ice, they must feel the effect of this expansion, and be driven towards the shore: since the force must always act in that direction. As no counter force exists to bring back the rock to its original position, the ultimate effect must be to crowd it entirely out of the pond; and perhaps to this cause we may impute the fact, that on the margin of some ponds we find a ridge of bowlders; while the bottom, for a considerable extent, is free from them.

The removal of rock masses in this manner was first noticed in Salisbury, Ct.; and a statement published in Vol. 9th of the American Journal of Science. I have seen no similar instance in Massachusetts; but Rev. Sylvester Holmes, of New Bedford, informs me, that an undoubted example of these travelling bowlders exists in a pond in Carver, Plymouth county; and that their track in the mud is quite obvious.

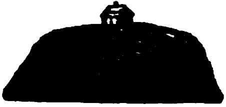
Action of the Sea upon the Coast.

It would not be proper in this place to go into the minute details of this subject. Where the combined and often conflicting agency of breakers, tides, currents, and rivers at their mouths, is to be taken into the account, it is obvious that very complicated effects must result: yet in general it may be stated, that the sea sometimes encroaches upon the land, and sometimes makes additions to it. Whether upon the whole these effects are balanced, is a question upon which geologists are divided in opinion. My object is merely to state such facts as have fallen under my notice in respect to the coast of Massachusetts.

Encroachments of the Sea.

The most remarkable example of this occurs in Boston Harbor. Here, as is well known, are numerous picturesque islands, the inner ones, nearly as far as the Boston Light, being composed chiefly of diluvium; though on their shores, at a low level, not unfrequently we find argillaceous slate and other rocks that occur on the main land. But all the islands outwards from the Great

Brewster, are merely naked masses of rock, and it would be natural to infer that the diluvium had been removed from these, even if we did not actually detect the process. But on the Great Brewster, the work is going on before our eyes. Its eastern side is a high bank of diluvium, obviously wasting away by the action of the waves that roll in upon it from the wide Atlantic; while the extensive beach along its southern side, is composed of the materials that have been swept away from its outer coast. The same process is seen going on upon the outer side of several other islands; and on Deer Island an extensive wall of stone has been erected by the U. States Government to arrest the progress of this degradation; which, if continued much longer there, would lay open the inner part of Boston Harbor to the fury of the northeasterly storms. From the same cause another of these islands, (I have forgotten which,) when seen from the northeast, exhibits an outline as regular, and with a single house near its centre, as fantastic as this drawing.



It seems to me that no man, accustomed to reason correctly from geological facts to their causes, can hesitate, in view of the appearances which these islands exhibit, to infer that all those outside of the Great Brewster have been deprived of their diluvial coat by the action of the ocean. Nor when we consider the frequency and violence of northeast winds and storms upon this coast, need we fear that the cause is inadequate to the effect; although it is not less than two and a half miles from the Great Brewster to the outermost of the Graves. It does not, indeed, follow, that all the intervening space between these outer islands was once solid land; so that the ocean has actually worn away 2 1-2 miles; and yet, this seems highly probable. Indeed, the mind is irresistably led to inquire whether the whole harbor has not been produced by the same cause; and when we see so many islands scattered over its bosom, which seem obviously the wrecks of one continuous diluvial formation, and perceive that the rocks, wherever they occur, are only a continuation of those occurring on the mainland, the most cautious reasoner can hardly avoid the conclusion that such was the origin of this harbor: or, at least, that this was a powerful auxiliary cause in its formation. Nay, it is difficult to see why the same reasoning will not apply to the whole of Massachusetts Bay; and when we see with what tremendous force the ocean must, for ages, have battered the hard sienitic rocks of Cape Ann, and what an immense accumulation of sand, gravel, and bowlders, has been made along the south shore of this Bay we feel almost prepared to adopt this theory. And yet, we are staggered in our belief when we reflect on the immense period of time requisite for such a work; and doubt whether other geological facts do not indicate a later commencement to the present order of things on the globe.

The proper place for learning the dynamical effect of northeast storms upon our coast, is on the north east side of Cape Ann. Rocks of many tons weight have been is this manner moved from their beds, and driven inward a considerable distance. One has only to visit this coast to be astonished at the marks everywhere exhibited of the powerful agency of a stormy ocean, and to be satisfied that nothing but the extreme hardness and unstratified structure of the rocks has enabled them to resist its violence. And when we learn that the rocks of Boston Harbor are softer and schistose, we see a sufficient reason why they have given way before the breakers; while Cape Ann, and the shores of Cohasset and Scituate maintain their position.

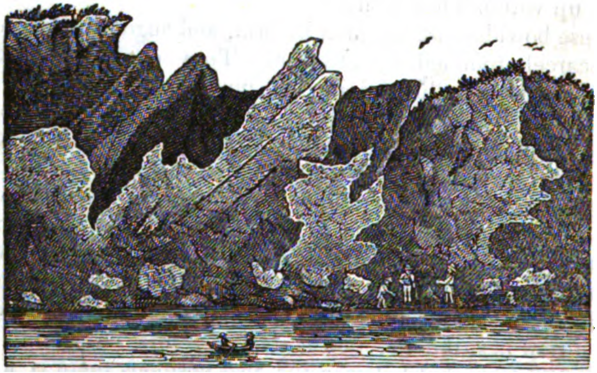
Since the publication of the first edition of this Report, I have received the following statement from Mr. Benjamin Haskell of Sandy Bay, on the northeast side of Cape Ann, illustrative of the power of the stormy waves of the ocean upon that coast.

'The northeast extremity of this Cape, known by the name of Flat Point, differs from the general features of the coast, by extending into the sea with a gradual slope, instead of the bolder aspect of the adjacent shore. Upon this point the sea beats during a northeast storm with a violence conceivable only to those who have witnessed it. Here, at the distance of from 60 to 100 feet above high water mark, lies what a farmer would call a winrow of bowlders, which there is every reason to believe have been thrown up within a few years.'

'These bowlders are irregular in form, and angular, their corners being scarcely rounded by attrition. They exceed in size any thing of the kind in this vicinity. A number of them would weigh 10 or 15, and some even 20 tons. But there is one far more interesting than all the rest; both on account of its greater bulk, and comparative regularity of shape, which renders the former easy to be estimated, and thus affords the means of ascertaining the maximum force of the Ocean in its anger. This rock was originally attached to a ledge about 5 feet above the level of the sea. The broken surfaces correspond so exactly as leave no room to doubt from whence it was detached. From this spot to the spot where it now lies, the direction is south, a little westerly. The distance 106 feet: but between the two positions there is a hollowing of the ledge (not a recent one) over which it must have passed, so that the ascent of the rock up this old-fashioned railway cannot have been less than 10 feet.'

'The weight of this bowlder has been calculated with care, due allowance having been made for irregularities of surface, and found to be rising of 28 tons. What an illustration of Hydrodynamics?'

Several cliffs of clay and sand along the coast exhibit the combined effects of the ocean, rains, frost, &c., in wearing away the land. In Chilmark, on Martha's Vineyard, is one of these facing the southeast, and at least a mile in length. It is now rare that the breakers rise high enough to impinge directly against the cliff: but they wash away whatever materials have been brought down by the rains. Gay Head, which is the western extremity of the same island, presents a cliff of variegated clays, sands, &c., not less than 150 feet high; and which standing exposed to the buffetings of winds and waves from the sea, and to the wastes of storms from above, exhibits perhaps the most instructive example along the shore, of the effects of these agents. In the second part of my Report, I described this cliff as a most picturesque object of scenery; but there is not likewise a more interesting spot in the State, to the Geologist. And among other things he cannot but notice the numerous fantastic forms into which the lofty masses of clay have been worn, while the numerous bowlders and pebbles along the beach attest the violent action of the sea. The following sketch, hastily taken, will give some idea of the aspect of the northwestern part of this cliff, as seen by a person standing on the beach below, close to the water. To exhibit it in perfection, the various lively colors of the different kinds of clay should be put upon it.



Oblique view of the Clay Cliffs at Gay Head.

A similar bank of clay occurs at the Light House in Truro, near the extremity of Cape Cod. It lies exposed to the unbroken fury of the wide Atlantic, and the marks of slow encroachment upon the land are quite manifest. Indeed, it is the prevailing opinion in that region, that this Cape is wearing away along the whole extent of its eastern extremity, and extending farther into Massachusetts Bay on the opposite side. I have no doubt that this is the case. For the general current on that coast is towards the south.

The same I presume is true of a considerable portion of the eastern shore of Nantucket. From data, on which Lt. Prescott places considerable confidence, he infers, that in one place, the loss of land within half a century, has amounted to 3 or 4 rods in width.

This advance of the ocean, however, must not all be imputed to the action of currents. For when once a sand bank of considerable height has been raised on the coast, the sea breezes will drive it inwards farther than the land breezes will bring it back. This inland march is quite obvious on Chatham Beach, in the situation af a swamp, which, 50 years ago, was in the centre of the beach ; but now lies near the eastern shore ; the body of the sands having moved farther west. A salt meadow formerly situated on the western side of the beach, adjoining the old north passage into Chatham harbor, has been covered up, and now begins to be disinterred on the eastern shore. A similar change of sides has taken place in a peat swamp on Nauset Beach ; which lies north of Chatham Beach, joining the mainland at Eastham.

I have described, in the second part of this Report, two excavations in solid rock in Newport, Rhode Island ; one of which is called Purgatory ; and these may be taken as a good example of the action of the sea upon a rocky shore.

Gain of the land upon the Sea.

Very frequently the materials that have been swept away by the sea, are again deposited by tides and currents along the same coast, forming low beaches. This is the case in nearly all the instances on our coast where the land is wasting away. Perhaps the most remarkable example is Chatham Beach, at the southeastern extremity of Cape Cod, which was probably all formed in this manner. On the Cape I was informed that this beach had advanced southerly, during the last 40 years, at the rate of a mile in eight years. Des Barres constructed a chart of this coast in 1772, and he says that the gain of this beach, for 30 years previous to that period, was 2 1-2 miles, that is a mile every 12 years.

An intelligent writer in the Barnstable Journal, however, has recently stated that it has advanced southerly only three miles in 70 years. He says that 20 years ago, this beach was an island ; and that there was a good harbor near its northern termination, which is now entirely filled up; so that no identation of the coast marks its former situation. Webb's island, also, situated not far from this harbor, is entirely washed away. In consequence of these changes, it is well known that the harbor of Chatham, once excellent, is nearly ruined; and nothing can save it from complete destruction but the forming of a new entrance.

Nauset Beach, already referred to, has likewise extended, according to the same writer, a mile southerly in 50 years; and it can extend no farther in that direction. In Nauset harbor the salt marsh has so much increased within 40 years, that 300 tons of salt grass are now cut where at that time only flats existed.

Monomoy Beach extends southerly from Chatham towards Nantucket; and has been formed in a similar manner by increments at its southern extremity. Not long ago the sea broke across the northern part of this beach, so that it is now an island.

Sandy neck extends eastward from Sandwich, nearly across Barnstable harbor, and it continues to advance in an easterly direction. There can be little doubt, also, that nearly, or quite the whole of Provincetown was formed in the same manner, and ought to be regarded as alluvial.

In like manner Smith's Point, which is a low sand beach constituting the southwestern extremity of Nantucket, has been produced by materials drifted thither by tides and currents from the eastern side of the island. When Des Barres constructed his chart, its extent was nearly the same as at present. But since that time, as Lt. Prescott informs me, it has been from one to two miles shorter. Whether the current that forms this beach passes around the northern point of the island, or along its southern shore, has not been ascertained: but it is certain that a current does set around the northern point, and thence along the northwestern shore, as certain facts prove, which I have not space to mention. And probably it is this current chiefly which has formed Smith's Point; and not unlikely, also, the islands of Thuckanuck and Muskegut, as well as the extensive shoals between Nantucket and Martha's Vineyard. It may be likewise, that another current passes along the south shore of Nantucket, aiding in this work, and forming Nantucket Shoals. And perhaps the irregular action of these currents, aided by unequal tides, may sometimes lengthen out, and at other times curtail the low beach of Nantucket called Smith's Point.

In several other places on the shores of Nantucket, there appears to have been an accession to the land, in the manner that has been described. But I am too ignorant of details concerning these spots, to be able to make any statements of interest about their progress or extent.

Considerations like the foregoing, often lead a man to feel as if such low sandy islands as Nantucket, and others in its neighborhood, were sliding from under his feet. But that no general change of position has taken place in them is obvious from the fact, that most of the cliffs on the shores of Nantucket at least, exhibit regular layers of sand and clay, demonstrating its general structure to be that of a tertiary formation, which has never been removed since its original deposition. True, if the world exist long enough, and these agencies continue to operate, the whole island will change its position. But as the work has progressed so slowly during the past 6000 years, the time requisite for its completion must be immensely great.

Dunes or Downs.

Sand is frequently thrown by the spray, or waves, during a storm, so high upon the shore, that the reflux waves do not carry it back. This being dried by the sun, is driven inwards by the sea breezes, and in the course of time forms hills of considerable elevation. Or sometimes the wind from the sea raises the sand from a cliff of tertiary formation, and carries it inland. Thus are formed those moving sand hills, which on the eastern continent, are called dunes or downs, and which have excited so much interest near the banks of the Nile. As might be expected, these dunes are common along the shore in the southeastern part of Massachusetts. They may be seen in the greatest perfection and on the largest scale, on Cape Cod; particularly near its extremity. They are frequently as high as 60 or 70 feet, and on the east end of the Cape, they move towards the west, but at what rate, in any instance, I was unable to ascertain. A series of these dunes, several miles long, threatens the village and bay of Provincetown, and large quantities of the beach grass have been transplanted to their ridges for the purpose of arresting their progress. I observed also, that the two species of the Hudsonia, which are common on the Cape, present no small obstacle to the advancement of these sands; though never transplanted, that I am aware of, for this purpose.

On both shores of Cape Cod throughout its whole extent, may be seen dunes more or less extensive; and by their snowy whiteness they sometimes give great interest to the landscape. I cannot learn that any of them have been productive of such extensive mischief to farms and villages as has sometimes resulted from their progress on the eastern continent. It would be strange, however, if the future history of Cape Cod should not contain catastrophes of this kind. Indeed, I have stated that they have aided in filling up the barbor of Chatham already.

Dunes of small extent, and of low elevation, occur on Nantucket, Martha's Vineyard, some of the Elizabeth islands, and in many places along the coast in the county of Plymouth. Moveable sand hills also occur rarely in the interior of the State; as, for instance, in the Connecticut valley, in Montague, Hadley, and in Enfield, Ct. But concerning these I know of no facts of special interest, except that they are slowly advancing towards the southeast; indicating the predominance of northwest winds.

Valleys.

Accurately to classify valleys, and assign probable causes for their origin, is one of the most difficult problems in geology. The man who takes only a hasty glance at the subject, is very apt to impute all valleys to the action of existing streams. But it needs only a slight examination to satisfy the observer that such a cause is totally inadequate to the effect. It will not, for example, explain the very common occurrence of one valley crossing another. Hence geologists have been obliged to resort to several causes to explain all the phenomena. The origin of one class of vallies, they refer to the original elevation and fracture of the rocks by a force acting from within the earth, and hence sometimes called valleys of dislocation. A second class they regard as the result of diluvial action at various periods, and hence called valleys of denudation. A third class they suppose to result from the agency of existing streams.

I am not aware that any attempt has yet been made to classify and point out the origin of the valleys of this country. Nor shall I attempt to do this in respect to all the valleys even in Massachusetts. I have no expectation of doing any thing like justice to so difficult a subject, except where long local residence has afforded ample opportunity for re-examination and reflection. I shall therefore confine myself chiefly to the valleys in the region of Connecticut river; though if I do not greatly mistake, these are by far the most remarkable and interesting in the State.

It is only those valleys which are the result of alluvial action that can be properly considered in this place. But as it will be more convenient to treat of the whole subject together, I shall here offer all the remarks I have to make upon it.

It is now generally admitted by geologists, that all stratified rocks must have been originally deposited in nearly horizontal layers, and subsequently elevated to their present inclined position by a force acting beneath. Such a disturbance must have produced many violent and extensive fractures in the strata and valleys of every shape. And since in the mountainous parts of Massachusetts, the strata are mostly primary and highly inclined, probably this is the manner in which most of our mountain valleys have been produced. If, as is now also generally admitted, the strata were elevated from the bottom of the ocean, the retiring waters must have acted powerfully upon the irregular surface, and considerably modified the forms of the valleys. The agency of rains, snows, and rivers, since that period, must have given them still farther modifications. Nor ought we to leave out of the account any other deluges of a date subsequent to that of the elevation of the strata, that may have swept over the land.

The valleys through which the Connecticut and its tributaries flow, are the largest and most remarkable in the State. The ordinary laws of physical geography seem here to be set at defiance; so much so, that a late ingenious writer* doubted whether I had correctly represented the 'Geology of the Connecticut,' because the course of the rivers, and the direction of the mountain ridges, were described as having so little correspondence with the rock formations. But the features of the geology, as well as of the scenery, along this river, are too obvious to be easily mistaken in their great outlines, which are alone concerned in this inquiry. The relation of the rivers to the different mountain ridges and rock formations, I hope to render intelligible by the aid of the accompanying Map, (See Plate XV.) on which are traced only the chief outlines of the surface. To present all the smaller irregularities of surface, I found would only obscure the points which I wish to illustrate.

That portion of the valley of the Connecticut to which I shall specially refer at this time, extends from near the north line of Massachusetts to Long Island Sound at New Haven. It is bounded by broad and generally lofty primary mountains; which, at the northern and southern extremities of the valley, converge until they almost meet, as may be seen on the Map. They are farthest asunder about in the latitude of Hartford. This valley is divided diagonally by a ridge of greenstone; commencing on the south with West Rock at New Haven, and extending, with few interuptions, to Easthampton, where it attains an elevation of about 1000 feet, and forms Mount Tom. Here it crosses the Connecticut, and on the opposite bank, forms Mount Holyoke; and continuing a few miles farther, terminates in Belchertown, as already described in the second part of this Report. This greenstone range is separated by vallies from the primary ranges at its extremities; and there are several places where it almost entirely disappears, as at the point in Hamden, through which passes the Farmington Canal: unless any are disposed to regard Mount Carmel in that town, as the southern extremity of the range, and the hills to the southwest, as a distinct range. Several other hills and elevated ridges of less extent, occur in this valley ; but it is unnecessary in this place to describe them.

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* Darby's View of the United States, p. 164.

In tracing the Connecticut through this valley, the geologist will be surprised to find it crossing the greenstone ridge above described, and that too in its highest part, viz. through the gorge between Holyoke and Tom. For he will naturally inquire, why did not the river flow through that part of the valley west of the ridge ; and following the course of the Farmington Canal, empty at New Haven ? For it appears from the surveys on that Canal, that in no place is that part of the valley more than 134 feet above the present level of the Connecticut at Northampton ; whereas the ridge through which it passes is from 800 to 1000 feet high. But the surprise of the geologist will be still farther increased, when he finds this river at Middletown, quitting the great valley above described, and passing over the remainder of its course through a deep ravine among primary mountains.

What inference shall we deduce from these remarkable facts ? Why, surely, that Connecticut river did not excavate its own bed ; for had the barriers at Northampton and Middletown been higher than 134 feet, above its present bed, it must have emptied into the Sound at New Haven. We must seek some other cause, therefore, for the origin of the passage between Holyoke and Tom, and for that through the mountains below Middletown.

Another inference is, that if the Connecticut ever formed a lake in its present valley, it must have been rather limited and shallow. For every place 100 feet higher than Northampton meadows at present, must have been above the waters. It may perhaps be thought that a barrier might have formerly existed at New Haven, which was subsequently worn down. But this would have been too mighty a work for any transient deluge to accomplish ; and the idea that the land was for a long time sunk beneath the ocean after the existence of the river, so as to be acted on by currents, cannot be admitted, because this would have destroyed the river. The existence of an extensive tertiary formation along the Connecticut, however, with horizontal strata, renders it probable that this river did once form a lake in its present valley ; though I have not been able to determine certainly whether this tertiary formation was formed beneath fresh or salt water.

Not less remarkable than that of the Connecticut, are the beds of its principal tributaries, the Deerfield, the Westfield, and the Farmington rivers. As may be seen on the Map, these all cross a high ridge of greenstone before they reach the Connecticut ; and in the case of Deerfield river particularly, the gorge through which it passes, not less than 250 feet deep, appears as if it must have been worn down for the express purpose of suffering the river to pass. And yet, this river has only to rise 80 or 90 feet above its present bed, in order to find a direct passage to Connecticut river on the south side of Sugar Loaf mountain. And so the Westfield and the Farmington might have passed down the western part of the Connecticut valley, and emptied at New Haven, had their beds been 100 or 130 feet higher than at present. And such must have been the course which all these rivers would have taken, had not the gorges through which they now pass in the greenstone ridges, been excavated for them before they began to flow, at least, to a considerable depth.

The direction of the primary strata, and the general course of the valleys in the mountainous region on the west side of the Connecticut valley, is north and south. But instead of following these valleys, Deerfield and Westfield rivers flow through ravines, running in general across the strata, and across the general course of the valleys. These ravines are, for the most part, very narrow and deep, and the edges of the strata on their opposite sides correspond. It seems difficult to suppose that these rivers have produced these ravines; and yet, since no similar ones occur in the region, one hesitates to say that they were not formed by fluviatile action. There is not certainly the same means of proving their existence previous to that of the rivers, as in regard to the gorges already described, through which these rivers and the Connecticut flow. Concerning the passage of Farmington river through the primary regions, I am too ignorant to be able to make any definite statements.

Terraced Valleys.

Although there is demonstrative evidence, that the rivers under consideration did not in all cases first excavate the valleys through which they flow, yet there is on the other hand, evidence scarcely less conclusive, that they have considerably lowered their beds since they began to flow. Between the primary mountains, from whence Deerfield and Westfield rivers, for example, issue, and the greenstone ridges through which they pass, they have formed alluvial basins, somewhat extensive, and sunk about 90 feet below the general level of the bottom of the Connecticut basin. And the banks of these basins are in some places curiously terraced; the different terraces being on a level on opposite sides of the basin. If we start from the edge of the stream at low water, and ascend a bank of 10 to 15 feet high, we shall come upon an alluvial meadow, which is frequently overflowed; and is consequently receiving yearly deposits. This may be regarded as the lowest terrace. Crossing this, we ascend the escarpment of a second terrace, 30 or 40 feet in height, which may be seen at intervals on the same level on all sides of the meadow. This second terrace is rarely very wide in any place, and seems to be only the remnants of a meadow, once much more extensive, which has been worn away. Ascending from this second terrace, 40 or 50 feet, up another escarpment, we reach the plain that forms the bottom of the great valley of the Connecticut. This constitutes the upper terrace.

The above description applies to the principal terraces existing on Westfield river, one or two miles west of the village, as well as those one or two miles east; and to those in Deerfield meadows, as well as those on the same river in the upper part of Charlemont. Smaller ones occur farther up the stream on Westfield river; also on one of its tributaries; and on Green river, a tributary of the Deerfield. I have also noticed imperfect terraces on Blackstone river, below Worcester. One quite distinct may be seen in West Brookfield, on a small branch of the Chickopee, which passes through that place. In short, terraces more or less distinct, exist on almost every stream of much size in the State, wherever the banks are low enough to admit of alluvial flats.

The banks of the Connecticut are less distinctly terraced in Massachusetts, than the smaller streams that have been noticed. Yet they exist on that river in several places within the limits of the appended geological Map. In Vernon, a few miles south of Brattleborough village, two quite distinct terraces may be seen on the west bank of the river. Between Turner's Falls and the mouth of Miller's river, the same number appear, though less distinct. In passing southerly, we find the same number on the west bank, in Pine Nook meadows, in the southeast part of Deerfield. In the south part of Sunderland, and north part of Hadley, on the east side of the river, two terraces appear, although they are at a greater distance than usual from the river. Traces of them appear also, in Springfield and West Springfield. In most of these cases they are discoverable on only one side of the river.

This peculiar arrangement of the sides of valleys, although scarcely ever noticed by geological writers in this country, appears to be very common on both sides of the Atlantic. Dr. Bigsby notices a striking case in Lower Canada; and Dr. Macculloch represents them as numerous in Scotland. They appear to be a distinct phenomenon from the *Parallel Roads*, so ably described by the last named writer.*

No observer will doubt but terraced valleys were produced, in some way or other, by the streams that now flow through them.

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* Geological Transactions, Vol. IV. p. 314.

And it is natural to impute them to the sudden bursting of the barriers of a pond or lake, through which the stream flowed; or to the sudden removal of an obstruction in a river, whereby its bed was rapidly deepened in soft soil, higher up the stream than the obstruction. If, for instance, the greenstone barrier through which Deerfield and Westfield rivers now pass, had been suddenly sunk a number of feet by some convulsion of the earth, or powerful ice flood, their beds would have been rapidly sunk by the waters in the soft meadows above the barriers; and thus terraces might have resulted. But I may be permitted to doubt whether any such sudden reduction of the river's bed is necessary to account for this phenomenon.

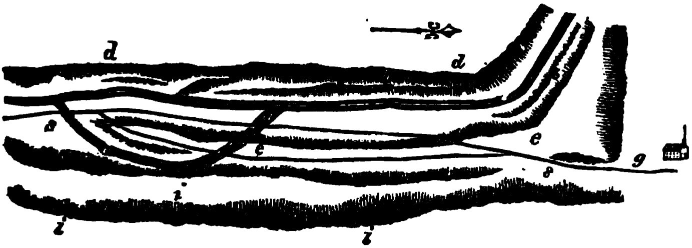
Let us suppose a period, when the bed of Connecticut river, in the mountaninous region below Middletown, was yet so elevated as to cause the waters to overflow the great basin between New Haven and Vermont. At that time, the mouths of Deerfield and Westfield rivers would have been on the western margin of this lake, or in the places where they now issue from the primary mountains. As the Connecticut wore down its bed, the lake would gradually drain off, leaving the tertiary formation, which its waters had deposited, perhaps 100 feet thick upon an average, with an almost entirely level surface. The Connecticut, having found its present bed, and the waters being drained from the valley, Westfield and Deerfield rivers must also excavate beds in the tertiary formation, above described, in their course to the Connecticut. Their course would no doubt at first be extremely serpentine, as that of rivers usually is, in flat countries. But as the bed of the Connecticut gradually sunk lower and lower, so would the beds of its tributaries sink: and then, would their waters, often swollen by rains, and obstructed by ice, begin to wear away the projecting banks, and convey them into the Connecticut. At length, the banks on either side of the rivers would be worn down and removed for a considerable extent. In other words, such basins as now exist at Deerfield and Westfield, would be produced; less deep, however, and destitute of terraces. As this basin enlarged, another process would commence. While the stream was confined within narrow limits, the alluvial matter, brought down from the mountains, would be carried along to the Connecticut. But as the basin enlarged, the water, when swollen by rains and melting snows, would spread over it, and becoming more calm, would deposit the mud and sand in suspension. Thus the new formed basin would be gradually filling up, and form an alluvial meadow But as the bed of the river would continue to sink, ere long the waters would rarely rise high enough to overflow the meadows; and for the same reason they could never be raised by alluvial deposition to the level of the plain through which the river first began to flow. The banks of the river having now become high, the waters would again commence their depredations upon them, and scoop out a second basin from the meadows just described. At length all these meadows would be carried away by the stream, except occasional patches, which would form a terrace around their margin. The second basin, having now become large enough to enable the overflowing waters to begin to deposite their mud and sand, a second meadow would be formed, which would go on rising and the river sinking, until the floods could no longer spread over them; when a third basin would be formed; and so on, as long as the river continued to excavate its bed.

I have confined this illustration to the basins of Westfield and Deerfield rivers, in order to render it more intelligible. But it can easily be applied to the Connecticut, or any other river.

Green River.

A hundred rods south of the village of Greenfield, on the stage road to Deerfield, Green River, a tributary of the Deerfield, has left indelible traces of having once run in a channel 40 or 50 feet above its present bed. At that elevation, a ledge of sandstone rocks bears the marks of having been once the bed of the stream, as distinctly as if it had run there but yesterday. The water here formed a cataract, 20 or 30 feet high; and below the ledge, a chasm, nearly as wide as the present bed of the river, is worn in the rocks several rods long, which communicates with the present channel. The pot holes left in the ledge of rock are some of them 6 or 7 feet deep, and one or two feet in diameter. The hill of sand and clay, which now rises abruptly on the west side of the present stream, probably once extended as far east as this cataract and chasm; and here was a ridge, which threw back the waters of the stream over the whole of Greenfield meadows, 4 or 5 miles in extent. For in various places along these meadows, we find terraces; generally two, but never more. The hill of sand and clay, at this gorge was probably worn away gradually; and as the surface of the sandstone rapidly slopes towards the west, this would cause the bed of the river to sink, and the terraces to be formed. In this way the bed of the river has changed laterally 10 or 12 rods, and sunk 40 or 50 feet.

Perhaps the following sketch may assist in rendering the preceding statement intelligible. It may not be entirely correct but it exhibits the principal features of the spot.



a, a, former bed of the river.
b, b, terraces: these are in the upper part of the gorge, and not in Greenfield meadows.
d, d, level of the Connecticut valley: a tertiary hill with steep declivity.
e, e, sandstone ledge.
g, Meeting House in Greenfield.
s, s, stage road to Deerfield.
i, i, i, successive ridges of sandstone more elevated than *d. d.*

Beds of other Rivers.

Judging only by the eye, I think we may safely state that since the Connecticut and its tributaries began to flow through the great valley that has been described, they have excavated their beds nearly 100 feet. The Connecticut at Northampton is still more than 100 feet above tide water at New Haven. At Springfield it is only 64 feet. This will give a descent from the latter place to the ocean of only a foot per mile, and considerably less if we subtract the height of Enfield Falls. South Hadley Falls make the principal difference between Springfield and Northampton. Indeed, the medium descent of this river from the foot of Turner's Falls in Gill, is probably less than a foot per mile. This is too small to enable the water to produce scarcely a perceptible effect in lowering their bed, for centuries, nay, not enough to prevent their filling it up. So that probably the process of excavation in the bed of that river, has nearly ceased.

Ice Floods.

There is, however, one agent of excavation, that still operates to some extent, even in the Connecticut; and that is, *ice floods.* Still more powerful is their effect upon smaller and more rapid rivers. Whoever has not witnessed the breaking up of a river in the spring after a severe winter, when its whole surface has been covered by ice several feet thick, has but a faint idea of the prodigious force exerted at such a time. The ice, high up the stream, is usually first broken in pieces by the swollen waters. Large masses are thus thrown up edgewise, and forced underneath the unbroken sheet, and the whole bed of the stream is blocked up; perhaps too, where the banks are high and rocky. The water accumulates behind the obstruction until the resistance is overcome; and the huge mass of water and ice urges on its way, crushing and jamming together the ice which it meets, and thus gaining new strength at every step. Often for miles the stream, prodigiously swollen, is literally crammed with ice, so that the water disappears; and a slowly moving column of ice is all that is seen. This presses with such force against the bottom and sides of the stream, as to cause the earth to tremble, like heavy thunder, to the distance of miles. Sometimes the body of ice becomes so large, and the friction so great, that the waters are unable to keep it in motion; and it stops while the river is turned out of its channel, and is compelled to flow in a new bed for weeks and even months.

It is impossible that such floods should not operate powerfully to modify the surface in alluvial regions, and to excavate the beds of rivers. I am confident that no other agent in the mountain torrents of this tate is so energetic. One has only to examine the banks and bed of a river after the ice has disappeared, as I have often done in Deerfield, to be convinced of this. But I apprehend that the maximum effect is seen in those rocky ravines, through which such rivers as the Deerfield and the Westfield pass, in the primary regions. Masses of rock of various sizes, even 10, 15, or 20 feet in diameter, may here be seen, some of them torn up from their beds and removed a considerable distance, strewing the bottoms of the streams, and at low water almost covering the surface; and others, only partially lifted from the parent rock, and waiting for another convulsive effort of the torrent to detach them, and give them an erratic character. In short, one sees in such streams a cause fully adequate to the production of those numerous bowlder stones that are scattered over the country: I mean, a cause sufficient to detach and round them. Probably, however, the expansive agency of water, frozen in the seams of these rocks, contributes not a little to lift them out of their original beds.

Valleys of Denudation.

When the strata of rocks on the opposite sides of a valley coincide, the conclusion seems inevitable that they once formed a continuous stratum, and that the valley has been subsequently excavated. The appearance in such cases indicates that it has been scooped out by running waters: and yet, this might be the appearance if water had only modified the sides and bottom of a fissure produced by other causes. And in some cases, at least, it seems necessary to call in the aid of other causes.

I am in doubt whether there is more than one valley in Massachusetts that is, strictly speaking, a valley of denudation. And that is the passage between Mount Toby, in Sunderland, and Sugar Loaf mountain, on the opposite side of Connecticut river. I have already described the appearance, and given a drawing of Sugar Loaf, and the geologist will at once perceive it to be a remarkable outlier, rising about 500 feet above the Connecticut, composed of red sandstone; whose strata dip to the east about 15°. On the opposite side of the river are red sandstone strata, dipping in the same direction. Sugar Loaf appears as if it had been modified by the action of water, even to its summit; and so on the opposite side of the river, I have already shown, in the second part of my Report, that Sunderland cave may be accounted for by the undermining operation of water upon the softer strata. And the valley of the Connecticut above this point exhibits none of those proofs that the river could not have excavated it, which exists as to the valley in general, and which I have already detailed. This subject however, I shall examine more particularly farther on.

Valleys in other parts of the State.

The remarkable and interesting valleys in Berkshire county, deserve long and careful study. After having passed across them and through them several times, my decided conviction is, that for the most part, they are valleys of dislocation, which have been more or less modified by deluges and other abrading agencies. The valleys in Worcester county seem to me to have had a similar origin; and I may add also the valley of the Merrimack. I mean that the original elevation of the strata gave to these valleys their great outlines. And the general parallelism of most of these valleys, agreeing also with that of the Connecticut, seems to indicate that nearly all the great valleys of Massachusetts were produced at the same epoch. But I hope to render this subject more intelligible when I come to treat of the systems of elevation that are found in our strata.

If it should seem that I have been very prolix in discussing the subject of Alluvium, I beg it may be recollected that it is one which excites at present an absorbing interest among geologists; and that scarcely no efforts have been made in this country to exhibit the dynamies of causes now in action. I hope this fact will afford me an apology for the imperfection of this effort.

2. DILUVIUM.

Under this term I include that coating of gravel, bowlders, sand, and loam, which is spread over almost every part of the surface, and which has been obviously mingled confusedly together by powerful currents of water, subsequent to the deposition of the regular strata. Hence geologists have referred it to the agency of a general deluge; and since it occupies the highest place in the rock series, except alluvial and volcanic rocks, most of them have regarded that deluge as identical with the one described in the Christian Scriptures. But recently some respectable geologists maintain, that existing causes, operating as they now do, might in the course of ages, have produced all the phenomena of the rock formations. Hence they deny the existence of such a deposit as diluvium; or, rather, they impute it to rivers, rains, frost, and other existing agencies, and include it under alluvium. Others, however, regard diluvium as the result of various agencies, operating at different periods; among which are the floods produced by the elevation of the rock strata at varidus times. But they do not admit that we have in this diluvium any evidence of a deluge contemporaneous with that described by Moses.

It ought to be remarked, however, that these geologists do not deny the occurence of such a deluge as is described in the Bible. Some of them, indeed, are clergyman, and they merely say, that geology does not furuish any evidence of such a catastrophe, although it affords no evidence to the contrary, but rather a presumption in its favor, in the fact so abundantly proved by the records of geology, that numerous extensive, if not universal deluges, have occured since the creation.

That a transient deluge, like that described in the Scriptures, could have produced, and brought into its present situation, all the diluvium which is now spread over the surface of this continent, will not, it seems to me, be admitted for a moment by any impartial observer. It has obviously been the result of different agencies, and of different epochs; the result of causes sometimes operating feebly and slowly, and at other times violently and powerfully. But the conclusion to which I have been irresistibly forced by an examination of this stratum in Massachusetts, is, that *all the diluvium, which had been previously accumulated by various agencies, has been modified by a powerful deluge, sweeping from the north and northwest, over every part of the State; not excepting its highest mountains.* And since that deluge, none but alluvial agencies have been operating to change the surface. I shall now proceed to give a history of this diluvium, with the reasons that prevent me from assigning its present modified státe to any other cause than a recent deluge.

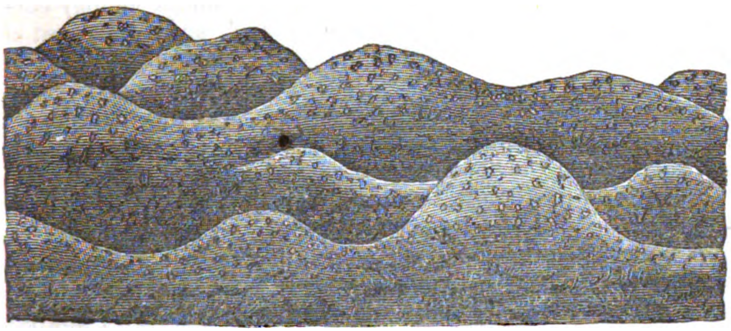
Topography of Diluvium.

The most extensive diluvial deposite on the Map, is in Plymouth and Barnstable counties. Indeed, nearly the whole of those counties (with the exception of the north part of the former,) might have been thus colored with perfect justice. But as I had good reason to believe that a granite ridge occurs where it is marked, concealed by a few feet of diluvium only, I thought myself justified in extending that rock on the Map nearly to the extremity of Cape Cod. I saw, however, no example of rocks in place throughout the whole extent of the Cape, except perhaps a single fissured rock, which has been powerfully acted upon by water; and which, if it be in place, is only the wreck of a granite ledge. A view of this rock will be given farther on. In Plymouth county, except at its northern part, the granite rarely appears, and but seldom forms a cliff even fifty feet high. Every thing, indeed, is buried by diluvium; and, as the streams are few and small there, it is extremely difficult to ascertain what is its geology, except to say that it is diluvial.

The diluvium of Plymouth and Barnstable counties consists almost entirely of white sand, some pebbles, and a very large number of bowlders of primary rocks. These bowlders consist chiefly of granite, sienite, and gneiss, with occasional masses of graywacke conglomerate, compact feldspar, and porphyry. They all correspond with the rocks found in place along the coast, in the vicinity of Boston, and on Cape Ann; and no one, it seems to me, can see the marks of degradation along that coast, who will not be convinced that a large portion of the pebbles and bowlders of Plymouth and Barnstable counties, must have come from thence. Along the range of elevated, and for that part of the State, even mountainous land, which is colored as granite on the Map, the bowlders are so enormously large, and so thick, that I cannot believe they have been ever removed far from their native beds. They are sometimes from 10 to 20 and even 30 feet in diameter, and frequently occupy nearly the whole surface; so that one can hardly persuade himself, when he examines them from a little distance, that they are not genuine ledges. Indeed, I have repeatedly been deceived by their appearance, until I had gone among them, and ascertained that they were detached bowlders. On the road from Sandwich to Falmouth is perhaps as striking an exhibition of this phenomenon as in any place, unless it be in the western part of Martha's Vineyard, in Tisbury and Chilmark. The same appearance is striking, also, in Brewster, on the Cape; and I doubt not that genuine ledges of granite may be found in those places; although (with the exception of Brewster perhaps,) I did not make the discovery. I have been informed, however, that rocks *in situ*, do exist in Dennis. But I have been so often deceived in this matter in that region, that I dare not state any thing as fact concerning it, which I have not carefully examined with my own eyes. At any rate, I cannot believe that bowlders so large and numerous have been removed many miles; for powerful as has been the diluvial current in the eastern part of the State, I have seen no well ascertained instance where whole mountains have been torn up and transported, as they must have been in this case, if they came from the region of Scituate and Cohasset, 40 or 50 miles; and that too, through a region of sand. And although much of the granite of these bowlders resembles that of Cohasset and Scituate, yet I doubt whether it is identical with it. Some of it I know to be quite different.

The sand, which is the predominant ingredient of the diluvium in the counties above named, was undoubtedly derived from a tertiary formation, which has been broken up by diluvial action. Remnants of this formation are occasionally seen on Cape Cod; and in Truro, so lofty and distinct are the cliffs of clay, that they have been noted on the Map. Clay is found in other places on the Cape; but not in large quantities, and generally at a low level. On Martha's Vineyard and Nantucket, this formation is much more abundant and obvious along the coast; though covered for the most part in the interior with diluvium several feet thick. Very likely this formation once occupied no small part of Massachusetts Bay, and probably also Buzzard's Bay.

In almost every part of the State the diluvium is piled up into elevations whose surfaces exhibit curves of every description; while the correspondent cavities are of various shapes. These convexities and concavities resemble very much the sandy or gravelly bottom of existing streams, where the current has been very violent; except that generally those in the diluvium are on a vastly larger scale. The following sketch may aid in imparting a correct idea of these diluvial irregularities. It was taken in the southeast part of Amherst, and exhibits several elevations from 10 to 20 feet high, composed entirely of gravel with no blocks large enough to be called bowlders.



Diluvial Elevations and Depressions: Amherst.

Standing upon the burying ground where rest the remains of our Pilgrim Fathers in Plymouth, we have around us on almost every side, and for a considerable distance, a fine example of these elevations and depressions. I mention this spot, not because it is more remarkable than many others for diluvial phenomena; but merely because it is so frequently visited.

In Truro, near the extremity of Cape Cod, the magnitude of these elevations and depressions is truly astonishing. One finds himself in a hilly and even mountainous country; the elevations being often from 200 to 300 feet high, and very numerous; and yet these are most obviously diluvial hills and valleys; that is, they are as obviously the result of currents of water, as those inequalities of surface, of exactly the same shape, which we find in the dry bed of a river. The fact is, this Cape, below Orleans, consists almost entirely of coarse sand, which is more easily piled up and scooped out than gravel; and this explains the striking features of the diluvium in the region of Truro, which is well worth a journey thither to examine. But one has only to look at a map of Massachusetts, to see that the idea of these effects having resulted from the action of any existing stream, is absurd; since no current of water, deserving the name of a river, can exist on that part of the Cape; whereas the Mississippi, or St. Lawrence, pouring through a mountain gorge upon a sandy plain, would be scarcely adequate to produce the effects here witnessed. And as to this being the result of the retiring or returning wave, when the strata were first elevated, I shall take occasion to show, before concluding this section, that the opinion is improbable.

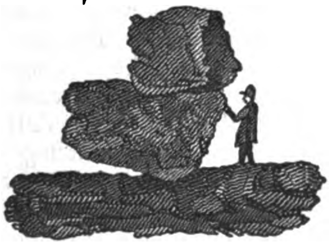
The same idea, of a force vastly greater than any now in action in the State, having been exerted in the production of our diluvium, forces itself upon the attention in many other places besides Truro. All the eastern part of the State presents evidence of having been swept over by a prodigiously strong current of water. Nantucket, Dukes county, and the Elizabeth islands, are almost entirely covered with a vast quantity of bowlders, gravel, and sand, most of which must have come from the continent. On Nantucket, bowlders and gravel are rare; only four or five large blocks occurring on the island; although masses two or three feet in diameter are not unfrequently met with: and these, consisting of granite, gneiss, and quartz, were obviously transported from the continent. On the Vineyard, the bowlders are very numerous, and some of them very large; and although some of them unquestionably proceeded from the mainland, yet in one or two places, as in Chilmark, I strongly suspect the existence of granite ledges a few feet below the surface, from the quantity and size of the bowlders: and yet one often sees very large blocks in the diluvial covering of the clay cliffs, as for instance at Gay Head; where one or two of them that have rolled down to the base, are from 20 to 30 feet in diameter. The Elizabeth islands are entirely covered by a thick coat of diluvium of a similar character; and so is the whole coast, from Cape Cod to Rhode Island, except that south of Rochester there is much less of sand; but the quantity of bowlders is prodigious; so that one often travels many miles without seeing a rock in place; although the surface is almost entirely covered by rounded masses of almost every size. This is seen on almost any road from New Bedford to Rhode Island.

Erratic Blocks and Rocking Stones.

Passing northerly from Buzzard's Bay, the whole country east of a line drawn from Providence to Boston, except the summits of a few of the highest mountains, and some alluvial valleys, is covered with diluvial blocks and gravel. But from Boston to the extremity of Cape Ann, embracing a considerable proportion of Essex county, the amount of bowlders is prodigious; and some of them are not less than 30 or 40 feet in diameter; and yet so powerful was the diluvial current, that these must have been removed from their original position, and many of them now occupy the summits of the highest hills in that region: presenting often a most singular outline to the landscape. When one of these erratic blocks is so poised upon a rock in place, as to be easily moved it constitutes a *rocking stone.* Some of these, weighing from 10 to 100 tons, can be perceptibly moved by the strength of a single man, applied to a lever; though the combined efforts of a hundred cannot move them, but a few inches. Of two of these rocking stones I have taken a sketch, on account of their peculiar appearance.

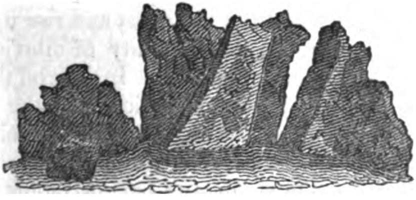
Rocking Stone in Chelsea.

The preceding shetch represents a mass of poryhyry, 10 or 12 feet in diameter, lying on a ledge of the same kind of rock in the north part of Chelsea, near the toll gate, on the Newburyport turnpike. The following is a view of a divided block of gneiss, which is nearly 10 feet high, and is so accurately poised upon a ledge of gneiss, that at a little distance it seems as if it could easily be thrown over; but this is no easy matter. It occurs in the west part of Barre, on the road to Dana.



Double Rocking Stone in Barre.

In Brewster, on Cape Cod, is an enormous mass of granite, 16 feet high, and 160 in circumference; of which a drawing is annexed. This is split into 6 or 7 pieces, and appears as if it had been subjected to a powerful action of water, or some other agent, in former times. Its size forbids the supposition that it has been removed from its bed; and probably it is the remains of a ledge which diluvial currents have worn away or buried. The sketch was taken from the west.



A Rent Rock in Brewster, Cape Cod.

I have noticed a rocking stone near the centre of Greenwich, weighing 30 or 40 tons, which might be moved by a lever. One may be seen in Chilmark, on Martha's Vineyard. In the 7th vol. of the Am. Journal of Science, is a drawing and description of one, of more than 46 tons weight, in Roxbury; which 'a child of six years old can easily move with one hand.' Mention is there also made of one on the Salem Turnpike; of three in the vicinity of Providence, one in Foster, one in Warwick, R. Island, and one in Framingham. Gen. E. Hoyt, also, describes one in the bed of Deerfield river, in Zoar. Indeed, they can doubtless be found in almost any part of New England.

But Cape Ann, of all other places in the Commonwealth, is the theatre of bowlder stones. Over a great part of the Cape, the trees and shrubs have been cut away; and in many places of great extent, the surface is literally covered by these rounded and erratic blocks. 'Thus must the world have appeared to Noah, as he came out of the ark,' exclaimed my travelling companion, as we came suddenly in view of a wide landscape near Squam, in Gloucester, studded with bowlders. The view is, indeed, a most singular one; and cannot fail to impress every reasoning mind with the conviction, that a deluge of tremendous power must have rushed over this cape. Nothing but a substratum of unyielding sienite could have stood before its devastating energy. The man who views this coast and that of Cohasset and Scituate, is no longer at a loss from what region the countless blocks of granite and sienite, scattered over the southeast part of the State, proceeded.

Mr. B. Haskell of Sandy Bay on Cape Ann, has furnished me for the present edition of this Report, with the following description of a rocking stone in that vicinity.

'We have a rocking stone within two miles of Sandy Bay, which is equal to any in interest, that I have ever seen described. Its shape, though tolerably regular, will not easily admit of its measurement. Yet, I have no hesitation in saying that it will weigh more than 45 tons. It can be moved by the effort of one hand, and its motion is perceptible at some distance. Formerly, it attracted attention. You will find it described in Mather's Magnalia.'

As we proceed westerly from the coast and rise upon the higher lands of Worcester county, the quantity of diluvium decreases; though in many places very abundant. In general the higher parts of mountains exhibit less of diluvial action than the lower regions. But it is usually at an intermediate level, and neither upon the highest nor in the lowest places, that the greatest amount of diluvium is accumulated. On steep and narrow mountains, we could not expect that much of this stratum would be detained, even if we admit that water could accomplish the Sisyphean labor of rolling rounded rock masses up steep and lofty escarpments. And in the lowest grounds, existing streams have to a considerable extent removed the diluvium, and in some instances covered it up. But there is no mountain so lofty in Massachusetts as not to exhibit marks of diluvial action. On Wachusett and Saddle mountains, indeed, very few rounded masses of rock from a distance are to be seen; though their own surfaces have been acted upon by a diluvial current, as I shall shortly state more definitely in speaking of another part of this subject. On the lower and less precipitous mountains of the State, however, bowlders of huge size, as well as gravel and sand, are abundant.

The valley of Worcester abounds in diluvium; especially in the north part of the county. Proceeding towards the Merrimack, through Sterling, Lancaster, and Groton, we find large accumulations of diluvial gravel, exhibiting the irregular convexities and concavities already described. We find in this region, however, much fewer large bowlders than in most other parts of the State. These become more numerous as we follow the Merrimack to its mouth. Much of the diluvium, however, from Worcester to Newburyport, consists of *shingle;* by which, I mean partially rounded fragments of slate, and quartz rock; resembling very much the pebbles occurring on the sea shore.

On the south of Worcester, the region of country sloping towards the Blackstone, especially on the west side of the river, exhibits striking traces of diluvial agency. In some places, as in Uxbridge, the bowlders of gneiss are large and numerous. As we proceed towards Providence, this stratum becomes thicker; concealing, indeed, nearly all the rocks in place; and in the vicinity of Providence a large proportion of sand is mixed with the gravel. This proceeds from the tertiary formation which occurs near Providence, as well as in the southeast part of Massachusetts, and which has been torn up in many places by the action of water. The sand abounds on the west shore of Narraganset Bay, nearly the whole distance to Newport.

The valley extending south from Oxford, through Webster into Connecticut, contains, especially on its slopes, an abundance of diluvium: so thick a coat, indeed, that the rocks in place are in a great measure hid; and hence it is quite difficult to ascertain the boundaries of the different formations.

Between the Worcester and Connecticut valleys, the country is mountainous; with deep and interrupted valleys, whose general direction is north and south. In some of these valleys the gneiss rock is covered for miles by diluvium, and by alluvium of disintegration. Indeed, this is often the case, in the more elevated parts of this region; though the diluvial waters seem to have exerted less power here, than in the lower land in the eastern part of the State.

The level part of the basin of the Connecticut, exhibits less striking marks of diluvial action than the smaller elevations on the margin of this tertiary plain. Some might even doubt whether the tertiary deposite of this valley is not postdiluvian. But I think that upon the whole, marks of diluvial action are too strong on its surface to be referred to the currents of an ancient lake. For the dilluvial coat is several feet thick in almost every place. We could not expect that a general deluge, of depth sufficient to rise above our highest mountains, would act as powerfully upon low and broad plains, as in the vicinity of mountain defiles and gorges, through which the water must have rushed with great power, even though its general movement was moderate. And this view accords with the present disposition of diluvium in Massachusetts. In Bernardston, Franklin county, for instance, which lies at the northern extremity of the Connecticut valley, we find a large amount of diluvium, which was evidently washed from the region of argillaceous slate lying north, through two or three narrow valleys, running north and south, down which the current must have rushed with great force. Accordingly we here find, on the road towards Northfield, a mile or two east of Bernardston centre, an example of diluvial elevations and depressions scarcely equalled in the State; exhibiting, as it were, the very gyrations of the mighty torrent. But when this stream spread out over the broad valley of the Connecticut, its violence and strength would greatly diminish; and hence this diluvium was not driven very far into that valley. Yet at the east end of Mount Holyoke, where it approaches the primary hills in Belchertown, we find a very powerful diluvial agency to have been at work, in consequence of the rush of waters through the gorge between the mountains, and also through the valleys on both sides of Mount Toby, and among Pelham hills on the north. So that in the southeast part of Amherst, and indeed through its whole eastern part, as well as in Belchertown and Ludlow, the diluvial sand and gravel are piled up and scooped out in a striking manner. And in general, as we begin to rise from the tertiary plain of the Connecticut basin, we find a greater accumulation of this stratum than on the plain itself, or high up among the primitive mountains.

In passing over the mountainous region between the valleys of the Connecticut and Berkshire, there is little in the character of the diluvium worthy of special notice, till we approach the summit of Hoosic mountain; when we are surprised to meet with an immense number of bowlders, which have been forced up the high and steep western escarpment of that mountain from the vallies of Berkshire. In these valleys, also, we find bowlders in abundance, which have been driven over the Taconnic range from the State of New York. But these facts will be examined more particularly farther on.

Along the western base of the Hoosic range, diluvium is accumulated in large quantities: but in general, this formation is not as abundant to the west, as to the east of Connecticut river.

As we pass from the Taconnic range to the Hudson, we find vast accumulations of diluvium. The fragments decrease in size as we approach the river, and within a few miles of it, diluvial elevations and depressions, composed of gravel and sand, are numerous and striking. The materials seem in part to have been derived from a tertiary formation, whose lower clay beds are still visible, a little east of Troy and Albany.

In Pownall, Vt., three miles north of William's College, is an unique and interesting example of diluvium. It lies on the eastern side of Hoosic river, against a hill of mica slate; and rises at least 100 feet. It consists of pebbles of quartz and micaceous and argillaceous slates, from three to four inches in diameter, down to coarse sand: and a part of the mass is consolidated into conglomerate and sandstone. (Nos. 25, 26, 27, and 28.) The cement is carbonate of lime; which having been dissolved in water, has been diffused uniformly through the mass. It is not perceived by the eye; but on applying acid, a brisk effervescence ensues; and hence I infer that it was infiltrated in a state of solution. And although I could perceive but few fragments of limestone among the diluvium, yet as the whole region abounds in this rock, it is hardly possible that it should not exist there, at least, in the state of sand. This being admitted, the consolidation of this stratum is easily explained by causes now in action; and a question might be raised, whether diluvium consolidated in this manner, does not in fact become alluvium. I ought to add, that when thus forming solid masses, it is as distinctly stratified as are most of our secondary sandstones and conglomerates.

How common may be consolidated diluvium in this country, I cannot say. But I believe no account of any other locality has been published. In Europe, geologists describe a similar rock, if Brongniart's *Terrains Clysmiens* is synonymous with diluvium; for he says that 'the parts of the rocks of that class are sometimes united by a base or cement chemically produced; that is by solution.' * At any rate, the consolidated shingle bed, described by Mr. Mantell in his Geology of Sussex, as occurring at Brighton, in England, must be regarded as of the same character as that in Pownall above described.

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* Tableau des Terrains, p. 66.

The most recent Deluge in Massachusetts.

The diluvial deposites in Massachusetts, whose topography I have now described, were probably produced originally, by all the abrading and disintegrating agents that were in operation on the surface of the globe, between the time when the solid rocks were deposited, and the last deluge. These agents, so far as we know, were the same as are now operating to modify the earth's surface; and have been described under alluvium. Hence there must be great diversity as to the times when the different portions of this diluvium were produced. But I maintain that all of it has been subject to the modifying influence of, at least, one general deluge of waters in more recent times. This deluge, as I have already stated, swept over Massachusetts from the north and northwest. The proof of this position I now proceed to exhibit.

The first part of this evidence consists in tracing erratic bowlders to the parent rock from which they were derived.

When I began an examination of the State, I travelled east and west; commencing with the line of towns bordering upon Connecticut, and returning through the line of towns next north. Thus essentially have I gone over the whole State. And I had not thus doubled my course many times, before I found, uniformly, that in order to trace bowlders to their original beds, I must travel north a greater or less distance. The discovery was frequently of great service to me; and I do not recollect that the principle ever failed me. I have, indeed, sometimes found a straggling block east or west, and even north of ledges of the same kind of rock; but never anything more than lonely stragglers. It will be expected, however, that on such a point I should refer to particular instances.

I have already remarked that granite and sienite constitute the great mass of the bowlders scattered over the southeast part of the State; and that these correspond to the rocks of this character on the coast that bounds Boston harbor. But similar rocks also occur in place, occasionally, in the region where the bowlders are found; and, therefore, we cannot be sure that they were transported from a distance; although in many cases the exact correspondence between the specimens would leave little room to doubt that such was the fact. But scattered among these primary bowlders, we frequently find others of porphyry, compact feldspar, and graywacke conglomerate; rocks, which (except the conglomerate,) occur only within a few miles of Boston, both north and south. I have found masses of porphyry as far down Cape Cod as Orleans;

and near the southern extremity of Martha's Vineyard, the pebbles of this rock are quite numerous. In Tisbury I have seen a mass of peculiar blood-red, compact feldspar, which occurs in place in Hingham; which would indicate the course of the diluvial current to be a few degrees east of south. The porphyry pebbles merely indicate a southern direction to the current; since the occurrence of porphyry at Half-way-rock, east of Marblehead, shows that this rock might formerly have extended far into the ocean. Graywacke conglomerate occurs in the graywacke formation in patches, from Rhode Island to Newburyport; and the bowlders of it above spoken of, must, therefore, have been transported in a direction a little east of south, in order to reach the west part of the Vineyard, where I found them.

We shall find abundant confirmation of this opinion in respect to the last named rock, if we pass from New Bedford to Rhode Island, either close along the coast to little Compton, or farther north, to Tiverton. The surface is covered with bowlders, chiefly of granite and gneiss. But occasionally we meet with masses of the conglomerate, whose diameter varies from one to twelve or fifteen feet. And by inspecting the Map, we shall see that the graywacke formation, from which they must have been derived, is very extensive in a north and northwest direction. Can there be a doubt that such was the origin of these blocks? If it was, then the diluvial current must have been powerful enough to move masses of this size, in some instances, not less than twenty miles. The region of country intervening, however, is not very uneven; and in estimating the power of running water to move rocks, we ought always to bear in mind, that they are but little more than half as heavy when immersed in water as in air.

Another instructive region, in respect to erratic blocks of graywacke conglomerate, lies on the east side of Taunton river, in Freetown and Troy. Along the river road the bowlders of this rock predominate; and yet I could not find any of it in place: but the rock there, so far as I could ascertain, is granite. These blocks, therefore, must have been transported from the opposite side of the river, in a south or southeast direction, in order to have come from a graywacke deposite.

In several places, as may be seen by the Map, the tracts of graywacke are bounded on the north by primary rocks; chiefly sienite, granite, and greenstone. And as we approach these primary rocks, from the south, even when eight or ten miles distant, we begin to find their rounded fragments; until at length, and that often at the distance of two or three miles from the primary ledges, they equal, or exceed in number, those of graywacke; rendering it often exceedingly difficult to ascertain the boundaries of the different formations. But on the other hand, no bowlders of graywacke are found in the primary regions lying north of the graywacke in place, except those very rare stragglers already alluded to; whose situation can be explained only by supposing a previous deluge in a different direction.

I think, however, that no geologist can examine the surface of the eastern portion of Massachusetts, without having the inquiry forced repeatedly upon his attention, whether the graywacke formation, that now exists only in interrupted basins from Rhode Island to New Hampshire, was not once continuous throughout this whole extent. The direction and dip of its strata, as well as its mineralogical character prove it to have been mostly produced at the same geological epoch; and the very powerful marks of degradation, which some of its varieties exhibit, especially the conglomerate, favor the opinion of its former continuity. And yet no one will presume to impute such powerful abrasion to any single deluge.

The particular towns, where we find the most striking examples of a mixture of bowlders of granite, sienite, and greenstone, with those of graywacke, which is the rock in place, are Attleborough, Mansfield, Norton, Bridgewater, Brighton, Newton, Needham, and Watertown. The Map will show, that a few miles northerly from these towns, are deposits of granite, sienite, and greenstone. On the other hand, in Stoughton, Randolph, Dover, Dedham, Braintree, &c., we find graywacke bowlders, mixed with those of the rocks in place; and these were obviously derived from the graywacke formations lying northerly from these places.

Perhaps the example more definite and decisive than any other on the subject under consideration, occurs in Rhode Island. In Cumberland a large hill exists of magnetic iron ore; a considerable part of which contains distinct crystals of feldspar, so as to become beautifully porphyritic. A rock so peculiar cannot be confounded with any other. Now if we pass along the north, east, and west sides of this bed of ore, even very near it, no scattered fragments of it are seen among the bowlders. But on the south side, they occur all the way to Providence, decreasing in size. Whether they may be found on the west side of Narraganset Bay, south of Providence, I cannot say: but I met with several pieces at the southern extremity of Rhode Island, in Newport, of only a few inches in diameter. These must have travelled nearly 35 miles from their bed, in a direction a few degrees east of south.*

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* An instructive example, similar to those in the text, is mentioned by Dr. Charles T. Jackson in his interesting paper on the Macles of Lancaster, just published, (June 1834,) in the first No. of the Boston Journal of Natural History. He says that an immense quantity of bowlder stones containing macles

In several places in the southeast part of Worcester county, I met with bowlders of a variety of porphyritic granite, distinguished from every other kind in the State, by its remarkably large imbedded crystals of white feldspar. But it was not till I came to Harvard, that I found this rock in place. On the north of the ledge, I never met with a single fragment. In Waltham, however, I did meet with one bowlder of this rock.

In the valley of the Connecticut, we meet with abundant traces of a diluvial current from the north. Thus, the diluvium which covers the red sandstone in the south part of Bernardston, and the north part of Gill and Greenfield, is composed almost entirely of detritus from the granite, argillaceous slate, and quartz rock, lying a few miles north. In Amherst, the diluvial pebbles and bowlders are granite, gneiss, hornblende slate, and red sandstone conglomerate; corresponding precisely with similar rocks in place in Leverett and Sunderland, six or seven miles north. But probably a fluvialist would regard all marks of this kind in the Connecticut valley, as having resulted from the action of the river when its barriers were yet unbroken below Northampton and Middletown. And this explanation would probably satisfy the mind, were it not for the evidence already exhibited, that the Connecticut could never have been more than 100 or 200 feet above its present level: an elevation not sufficient to produce the diluvium that has been described.

Another class of facts is still more inexplicable on the fluvial hypothesis. On the east side of the greenstone and sandstone range, which passes through the west part of West Springfield, and which rises into mount Tom in Easthampton, we find mixed with the bowlders of sandstone and greenstone, many others of a peculiar sienitic granite, which occurs in place, on the west side of the range above mentioned, in Northampton, Hatfield, and Whately. These must have been driven over the greenstone ridge by a northerly current: and yet, some of them are two or three feet in diameter, and the ridge is several hundred feet high. As we go northerly, still continuing on the east side of the greenstone, the number and size of these bowlders increase. We find them even upon the summit of mount Tom; though as we ascend this precipitous peak, their number and size diminish; so that on the top, I never saw one more than six or eight inches in diameter.

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occur on the southeast side of the hill, where they are found in place: but none on the northwest side of the hill. 'This fact,' says he, 'I consider of value in geology, as it concurs with so many others, to prove, that at some period since the creation, there has been a powerful current of water rushing over our continent from the northwest towards the southeast. It is highly probable that this was effected by that last grand cataclysm which overwhelmed the world, and to which the traditions and religious belief of every nation give ample testimony.' p. 55.

Now this mountain rises nearly a thousand feet above the plain which lies to the northwest; and on that side it presents a mural face several hundred feet high. Yet these bowlders must somehow have been forced up this precipice; since the bed from which they originated lies in a northerly direction from the mountain.

On the banks of the Westfield or Agawam river, in the west part of West Springfield, I found small bowlders of quartz, containing galena and blende. Both the matrix and the ores correspond exactly with those found in Southampton, Williamsburgh, and Whately. All the metallic veins in those towns lie in a northerly direction from the spot where the bowlders were found; and there can be little doubt that they originated thence.

If we go to the large beds of serpentine in Middlefield and Blanford, we shall find bowlders of this rock on no side of them but the south. On that side, they are very numerous at first; and continue to decrease in number and size as we recede from the bed. I noticed this fact most strikingly around the most northern bed of serpentine in Blanford. In some instances, however, as in the serpentine bed in Westfield, fluviatile action removed the bowlders in a different direction. The Westfield river, in that instance, runs easterly and crosses the serpentine; and of course has carried bowlders of it in that direction.

As we ascend the broad and lofty mountain range, west of Connecticut river, we meet occasionally with rounded fragments of well characterised granular quartz; and their number and size increase till we reach the western base of Hoosic mountain. But in vain shall we search for this rock in place till we have begun to descend Hoosic mountain. Along its western base are extensive ledges of this rock, across the whole extent of Massachusetts, and extending far into Vermont. And in going westward, the bowlders increase in number and size till we reach the rock in place. These facts lead to the conclusion, that the diluvial current in this part of the State, came from a direction nearly northwest. This opinion is confirmed by finding numerous bowlders in the valley of Berkshire, of graywacke; an extensive formation of which, reaching nearly to Hudson river, commences a few miles beyond the western boundary of the State. Some fragments of this rock were found by Dr. Emmons in Chester, on the eastern slope of Hoosic mountain; establishing the same conclusion. The force of this current must have been very great, if it took place since the surface of Berkshire county assumed its present inequalities. For bowlders of several tons weight are found lodged at various elevations, on the steep western escarpment of Hoosic mountain; and as already remarked, these bowlders, in large numbers, have been actually carried over the top of the mountain, and driven southeasterly from 10 to 20 miles. I even found a fragment of quartz breccia, a foot in diameter, in Easthampton, in the valley of the Connecticut. It was of so peculiar a character, that its parent rock, on the west side of the Hoosic, could not be mistaken. To suppose that these quartz bowlders were forced by a current of water up the steep side of this mountain, from 1000 to 1500 feet, if that current was at right angles to the direction of the mountain, is absurd. Yet as the direction of the current was very oblique to the direction of the mountain, it is possible that there might have been power enough in it for the work. And it ought also to be stated that the quartz rock in Clarksburg seems to be a spur from the Hoosic range and rises to an almost equal elevation, although a valley of considerable depth intervenes. In the east part of Cheshire, also, as well as in Savoy, the quartz rock exists *in situ*, at a high elevation; especially a variety that is interstratified with gneiss. And no deep valley intervenes between its locality and the top of the Hoosic range. The situation of several valleys, also, along the western slope of this mountain, is very favorable for enabling a northwesterly current of waters to drive bowlders up the declivity.

The graywacke bowlders which are scattered over the valleys and hills of Berkshire, and which are sometimes of several tons weight, must have been forced over the Taconnic range of mountains. But the western slope of this range is not generally as steep as that of the Hoosic; and in several places transverse valleys occur: or rather depressions of the summit: as for instance, the ravines through which the principal east and west road passes in Hancock, and between Canaan and West Stockbridge. Still, a prodigious force must have been exerted by the waters in carrying over this ridge such an abundance of coarse detritus.

Indeed, some may suppose it necessary to refer this diluvial action to a period preceding the elevation of the strata: for to suppose it produced by that elevation, will not relieve the difficulty; since the wave produced by the rise of the strata, would not act till Hoosic mountain was actually thrown up; and besides, that wave must have flowed from the west to the east; whereas the current that moved these bowlders must have come from a direction not far from northwest; as appears from the diluvial grooves and scratches on the rocks, which I am about to describe. But if these bowlders were removed by currents previous to the elevation of the strata; that is, while they were yet in the bottom of the ocean, how does it happen that the blocks are accumulated along the western base of the Hoosic, and along its steep face, just as they would have been, if they had met with that mountain to obstruct their progress.

Wherever, we find valleys passing obliquely up the face of this mountain, especially those running in a southeasterly direction, we find them abounding with the peculiar quartz bowlders that have been described, just as would be the case if these had been driven up said valleys by water after their excavation. Had the bowlders been spread over the surface before the existence of the valleys, why should they be so much more numerous in those valleys, than upon the hills? Alluvial agents would, indeed, tend to accumulate them in valleys: yet by no means to the extent to which we now find them, especially in broad valleys.

Upon the whole, I have no hypothesis on this subject to propose, more free from difficulties, than that which imputes the removal of these quartz and graywacke bowlders, in a southeasterly direction, to the same debacle of waters, which, in other parts of the State, has swept the detritus southerly. What local cause should have deflected the current towards the east, in the western part of the State, and in the eastern part of New York, I can hardly conceive: though, I shall shortly endeavor to show, there was considerable irregularity in its direction in that region; enough, perhaps, to lead to the suspicion, that the deep valleys and ravines, through which the waters must have rushed, might have considerably modified their course. But I think that the change of a few degrees in the direction of the current, is not so great an objection to this hypothesis, as the Sisyphean task, which must have been accomplished, if it be true, of urging upwards, over so long and steep inclined planes, bowlders so large and so numerous. Making every allowance for the reduction of the gravity of these bowlders when in water, I confess, I cannot conceive how such a work could have been effected by this agency. Yet neither can I conceive how those diluvial elevations and depressions, that have been described in various parts of the State, could have been produced by a deluge. For they are on so large a scale, as to transcend by far, the maximum effect, which I can conceive to be produced by a flood of waters. Still it is undeniable that these did result from such an agency. Hence I may underrate the power of that same agency in the removal of detritus.

I acknowledge, however, that I should be inclined to refer the diluvial phenomena in the western part of the State, to a different and an earlier deluge than the last—perhaps to the retiring waves when the strata were first elevated—did not facts forbid it. I have mentioned some of these, and shall soon mention another still more conclusive.

In stating the facts relating to the bowlders of sienite on mount Tom, I have shown that the difficulty of accounting for their situation, is not confined to the west part of the State. Another case still more remarkable, exists on mount Toby; although not embracing so wide an extent of country. To the height of several hundred feet, the eastern side of that mountain is very steep; forming, indeed, in some places, a mere precipice, very difficult to scale. A narrow valley separates this side of the mountain from the extensive gneiss range lying easterly, and rising gradually into mountain ridges, nearly as high as Toby. Now on this steep eastern escarpment of Toby, even to its summit, we find scattered bowlders of gneiss, having precisely the characters of the gneiss in the north part of Leverett and in Montague. True, the gneiss range extends so far to the west in Montague, that a current of water from the north, or from a few degrees east of north would carry detritus towards the eastern slope of Toby. But how is it possible that any aqueous agency could have driven it up so steep a declivity? There are three remarks that may afford the mind a little relief, perhaps, in this difficulty. One is, that on the northeast side of Toby, are several ravines, running northeasterly, with brooks at their bottom; and these might have once presented slopes less difficult of ascent, than at present. Another is, that the conglomerate rock of Toby, may have been much worn away by alluvial agents since the removal of these bowlders, and consequently the eastern slope of the mountain may have been formerly much less precipitous. Indeed, the great quantity of huge rocky masses that lie along the base, renders such a supposition probable. Finally, these bowlders may have been removed to their present situation ere the valley on the east side of the mountain existed, and before the elevation of the strata into their present situation. For I know of no circumstances in the region, that are opposed to such a supposition.

There is also a suggestion that I wish here to make, respecting all those bowlders which have been forced up steep declivities by a force apparently greater than we can imagine water alone to exert. We do know that where large masses of ice are frozen to the earth and suddenly torn up by a deluge, or where a swollen current urges along large quantities of ice, numerous bowlders, and those of great size, are often thus borne up and removed to a great distance. Now may not this cause of removal have been in operation at the period of the last deluge? Especially may we not admit this, when we have such conclusive evidence that that deluge came from the north? Must not the polar ice have been driven southerly in great quantities? And might not the temperature of this part of the globe have been so raised, that during the continuation of the deluge, those masses of ice might have been frozen to the bowlders in the vallies so as to lift them from the soil when the waters become more violent or have risen higher?

I have also been led by the phenomena of ice floods to inquire, whether many of those immense elevations and depressions which some of our diluvium exhibits, might not have partly resulted from the same cause? For where a stream has been turned from its bed by such a flood, and gone for weeks to find its way through the crevices of large fields of broken ice, it sometimes scoops out cavities and raises hillocks little inferior in size to those occuring in our diluvium. Might not the diluvial waters have operated in the same way, after having covered the surface of our continent with vast accumulation of arctic ice?

I throw out these hints in the feeble hope that they may shed a ray of light on an obscure and difficult subject.

Mixed with the granite bowlders on the eastern slope of Hoosic mountain, are masses of a peculiar kind of granite, distinguished by its unusual tendency to disintegration. The parent rock, from which it was derived, I have never yet discovered; but predict that it will be found along the western side of Hoosic mountain, in Clarksburg, or farther north.*

Diluvial Grooves and Scratches upon the Rocks in Place.

The second argument that shows the direction of the last diluvial current in Massachusetts to have been towards the south and southeast, is based upon the existence of grooves, furrows, and scratches, upon the surfaces of the rocks, that have never been moved from their place. The water-worn appearance of those rocks, in every part of the State, which are undergoing no disintegration at their surface, must, it would seem, arrest the attention of a very careless observer: although I have been surprised to meet with so few men who have noticed the fact. In some cases, however, the rocks are not merely smoothed, but are grooved and furrowed, as if heavy and irregular bodies had been dragged over their surfaces. The following sketch exhibits a rock of this description near the turnpike, from Boston to Chelmsford, near the one between Bedford and Billerica, and not far from the sixteenth mile stone from Boston. The rock is intermediate between gneiss and mica slate. Its strata seams run in the direction *a*, *a*; and the grooves and scratches in the direction *b*, *b*.

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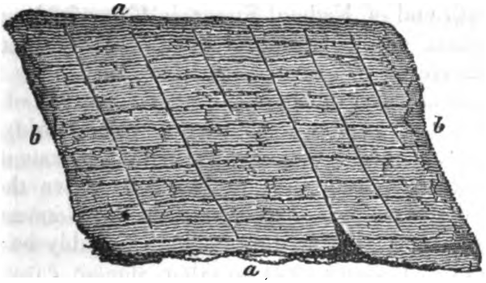
* Since the publication of the first edition of this Report, Professor Emmons has informed me that this conjecture is true. I have accordingly exhibted on the geological Map accompanying the present edition, a patch of granite in that place.



Diluvial Grooves in Gneiss: Billerica.

The direction of these grooves is nearly north and south; and this is their general course in every part of the State, east of Hoosic mountain. Commonly, however, they run a few degrees east of south, and west of north. I shall first mention several localities where these furrows correspond in direction to this description, and then notice a few anomalous cases in the west part of the State.

One hundred rods east of the village on Fall River, in Troy, are grooves and scratches on granite. Some of the bowlders lying on the surface here will weigh from 50 to 100 tons.

Similar grooves occur on a road leading from the south part of Scituate to Hanover four corners. The rock is granite.

Also in Abington, Randolph, Canton, Sharon, Dedham, and Dover; on granite and sienite; very common.

Also on the conglomerate in Dorchester.

In passing from Worcester to Berlin, through Boylston, the like appearances present themselves frequently on the surface of the gneiss and mica slate.

Likewise in several places between Andover and Boston, on granite and sienite.

The high hill of gneiss in the centre of Rutland, exhibits the same.

On the top of Wachusett mountain, 3000 feet above the ocean, a few rods northwest from the prospect house, these furrows may be seen; though less distinct than in many other places. The rock generally on that side of the mountain, appears distinctly waterworn.

In Westford, one mile north of the meeting house, on the road to Dunstable, is a fine example, on mica slate.

In Marblehead, on sienite, 15 rods southeast of the residence of the Hon. William Reed, near a meeting house, are quite distinct furrows.

They appear on gneiss, near the meeting house in Petersham, though not very distinct.

At the north end of Federal Street, in Greenfield, and also half a mile northeast of the Episcopal church, on the road to Gill, these grooves are very distinct, on red sandstone.

In the southeast part of Deerfield, near the banks of Connecticut river, about two miles north of Sunderland bridge, they occur on trap rock. Also very distinct and numerous in the north part of Sunderland, from 200 to 400 feet above the river, on sandstone and greenstone. Other cases in the Connecticut valley might be mentioned; but as they might reasonably be imputed to fluviatile action, if there were no other similar cases on higher ground, I shall omit them. Indeed, I am in this case inclined to believe them of fluviatile origin: except perhaps where, as in Gill, we find grooves on the tops of the highest hills.

Between Whitingham and Wilmington, Vt. are numerous cases on gneiss and mica slate.

A very fine example occurs on the lofty hill in the north part of Rowe. This hill rivals even Hoosic mountain in elevation. Near Rowe meeting house, is another example. Fifty rods south of the meeting house in Heath—a point higher than the the centre of Rowe—are several other, though no very striking examples.

In Blanford is one of the most striking examples of diluvial grooves in the State. The hill half a mile north of the congregational meeting house, where it occurs, is very high; overlooking all the surrounding mountainous country.

A similar example may be seen near the meeting house in Norfolk, Ct. Also on Canaan mountain, 4 or 5 miles south of Massachusetts line.

On the conglomerate in the southeast part of Newport, Rhode Island, may be seen diluvial scratches, running from 10 to 20 degrees west of north and east of south.

From what has been said concerning the distribution of bowlders as we approach the western part of the State, we should expect that these furrows would there have a direction nearly northwest and southeast. Accordingly, near the turnpike from Greenfield to Williamstown, on the top of Hoosic mountain, which is about 2400 feet above the sea, we find grooves on the mica slate, running W. 20° N. This is near the eastern margin of the mountain. They occur, also, near the western margin; having nearly the same direction. In the northwest part of Windsor, just where Hoosic mountain begins to slope westerly, I found grooves running nearly north and south. But for 3 or 4 miles easterly from the meeting house, are numerous distinct cases where the course is almost exactly northwest and southeast.

In the west part of Worthington, which is several miles east of the top of the mountain, these grooves run W. 30° N. But in Middlefield, where they abound near the meeting house, and the residence of Gen. Mack, they run much nearer north and south. On that part of Saddle mountain, call Bald mountain, also, are faint scratches, very difficult to examine on account of their coinciding so nearly with the direction of the layers of the rock. But they run not far from north and south. Gray Lock, which is several hundred feet higher than Bald mountain, is so covered with vegetable mould, that I had no opportunity to discover diluvial furrows, if they exist there.

In passing from Albany, N. Y. to West Stockbridge, Massachusetts, through Greenbush, Schoodack, Nassau, and Chatham, I met with several examples of diluvial grooves upon the surface of the graywacke; particularly in Schoodack and Nassau. Their direction was almost uniformly N. W. and S. E.; though sometimes approaching a few degrees nearer to north and south. The surface of this rock in general, especially of the slaty varieties, is too liable to decomposition to retain for centuries the marks of former abrasions; and I was rather surprised to meet with any instances. Yet I am satisfied that some rocks retain these marks, although their surfaces have suffered disintegration to a much greater depth than that of the grooves. For since the disintegration takes place at the surface only, the grooves and correspondent ridges may remain, although layer after layer scales off. Yet the ridges will be liable to suffer rather the most from atmospheric agents; and, therefore, in some rocks, they will probably soon disappear.

It may be well in this place to suggest a caution against mistaking the structure of the rock as revealed by disintegration, for these diluvial furrows. Some varieties of mica slate exhibit a surface extremely resembling one mechanically grooved. But in that rock, the direction of these pseudo-grooves always corresponds with that of the layers of the rock; and thus the deception may be discovered. But sienite and greenstone, which contain segregated veins, sometimes present cases that are very perplexing. One of these may be seen on the top of mount Tom, a few rods north of the signal staff, erected for the Trigonometical Survey of the State. The prevailing direction of the apparent furrows there, is nearly north and south; and did they not run east and west within a rod or two of the spot, I should have put down this as a genuine case of diluvial grooves. But examination, after my suspicions were excited by this circumstance, satisfied me that it is only the internal structure of the rock, that is here revealed by the unequal disintegration of the surface.

But to return to a consideration of the diluvial grooves in the western part of the State: I think it obvious, from the examples that have been adduced, that the general direction of the waters there, as well as in the eastern part of New York, must have been from northwest to southeast. The two exceptions mentioned, I think may be explained by their local situation, in consistency with this supposition.

Now these furrows on Hoosic mountain, and in New York, are as distinct as in other parts of Massachusetts: and, therefore, we must consider them all as produced at the same epoch. Had there been any great difference in the time of their production, especially had one set of them been the result of the elevation of the strata, and the other of the last deluge—events that form almost the limits of geological changes in point of time—the oldest must have been lost, or become obscure. Whatever difficulties attend the supposision, therefore, I think we must regard all these diluvial grooves in the State as having resulted from the same deluge.

It would be easy to multiply examples of this kind of diluvial action. But the cases that have been described, occurring as they do in every part of the State, and frequently upon its highest mountains, seem sufficient to lead every reasonable man to the conclusion, that these grooves and furrows were produced by the large bowlders, which now strew the surface, and exhibit in their rounded forms and smooth surfaces, the marks of powerful abrasion And since we uniformly find these bowlders to the south and southeast of their parent rock, how can we doubt that a mighty current of water has sometime or other swept over the surface from the north and northwest? It seems to me, that in regard to Massachusetts, the evidence of such a deluge is complete; and it is difficult to see how it could be more conclusive.

Origin of the Diluvium of Massachusetts.

It is maintained by those geologists who account for all geological changes by existing causes, acting with no greater intensity than at present, that most of the stratum which I have described as diluvium, has been produced and brought into its present state by the action of existing streams, rains, frost, and other agents now in operation. But the simple fact that the current must have had a southerly direction in every part of the State, and has left traces of its action on our highest mountains, renders such a supposition, it seems to me, altogether untenable. For how could rivers have risen so high; or how, unless it were a single river, not less than 200 miles wide, could the waters have produced such effects? The same difficulty is in the way of supposing, as do some fluvialists, that the land was once much lower than at present, having been gradually elevated by earthquakes. Admit, if it be wished, that the surface was once much lower than its present level: the difficulty will still be to find a current 200 miles wide.

Other geologists, who perceive the utter insufficiency of such causes to account for diluvium, have imputed very much of it, and also diluvial grooves and furrows, to the retiring waters of the ocean, when first the solid strata were elevated. I doubt not that such was the origin of much of the diluvium that now covers the globe. But I think it quite obvious that all the diluvium in Massachusetts, which was produced by this and other causes, has been modified by a deluge long subsequent to the elevation of our continent from the ocean. For by examining the sections of our rock strata, appended to this Report, as well as the Map illustrative of the course of the same, it will be seen that their prevailing dip is easterly, and their general direction north and south. Hence the anticlinal line of these strata, that is, their axis of elevation, must be sought farther west than Massachusetts; and, consequently, the retiring waters must have rushed from the west at that epoch. But the actual current of the last deluge came from the north and northwest, as I have abundantly shown; and therefore, it could not have resulted from the elevation of the strata.

In the eastern part of the State, however, it will be observed that the strata of the graywacke formation run generally east and west. But they dip northerly; and hence the current of water, which their elevation produced, must have been towards the north; though if we suppose it to have been southerly, this formation is too limited in extent to account for diluvial action over the whole State.

But there is another circumstance, showing that the last deluge that swept over this State, was long subsequent to the elevation of the strata. If we admit, what I think is true, that the tertiary formation exhibited on the Map along Connecticut river, was deposited before the last deluge, it will follow that the elevation of the strata could not have been the cause of that deluge. For the strata of this tertiary formation are horizontal; and, therefore, must have been deposited after the elevation of the strata of the solid rocks beneath. Otherwise the strata of the tertiary formation would also have been raised and dislocated. Hence there must have been, at least, an interval long enough, between the elevation of the strata and the last deluge, for the deposition of this tertiary formation. And if we take the statement of Dr. Macculloch,* in respect to the filling up of the lakes of Scotland, as a standard of comparison, this will be shown to have been no ephemeral period. He states that these lakes 'shoal' at the rate of half a foot a century: and I apprehend that the tertiary formation under consideration cannot be less than 150 feet in depth. Nor can we suppose that this is but a small part of the period that actually intervened between these two events: which may be regarded as almost the first and the last of the geological catastrophes that have happened on our globe. This opinion might be sustained by an appeal to facts and principles: but I conceive that this is not the proper place for entering into such discussions.

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* Macculloch's System of Geology. London, 1831—Vol. I. p. 507.

I may seem here, however, to be advancing opinions contradictory to the Mosaic chronology of the globe. But they are simply opposed to the prevaling interpretation of that record. If we only suppose, what many of the ablest theologians and philologists maintain, and what geological researches imperiously demand, that Moses, after describing in the first verse of his history, the original creation of the universe 'in the beginning,' passes over in silence a long intervening period, before he gives us an account of the earth in its present state, and of the creation of its present inhabitants, all apparent collision between geology and revelation vanishes. Such an opinion I have adopted, not merely because facts in geology demand it, but because it seems equally required by a fair interpretation of the language of Moses.

But to return from this digression; it seems to me that the fair result of all the facts and reasonings which I have presented on the subject of diluvial action is, that a mighty deluge has swept from the north and northwest over every part of Massachusetts; and that it cannot be accounted for by the original elevation of the strata of rocks; nor can our diluvial phenomena be explained by the agency of rivers, rains, frosts, or any other causes acting with their present intensity. This deluge must, then have occurred since the earth's surface assumed essentially its present form: and was the last of those catastrophes to which this part of the globe has been subject; and which cannot be referred to existing agencies. The inquiry naturally arises, whether this deluge was identical with that described by Moses. I have already remarked that this question can have no very great interest as bearing upon the veracity of the sacred historian; since nearly all geologists agree that their science exihbits no evidence against the occurrence of such a deluge as he has described. Yet, as it is a characteristic of human nature to go from one extreme to another, and as it has been customary to impute almost every geological change to the deluge of Noah, is it not probable that philosophers, disgusted with so much false reasoning on the subject, will be apt to overlook even creditable geological evidence of that event? I have shown, if I mistake not, that the last deluge in Massachusetts was universal, and that it was comparatively recent. The deluge of Noah is described as universal over the globe; and historical records give us no account of one more recent. Where then is the objection against considering them as identical? Until some substantial reason can be given against such a conclusion, is it not unphilosophical to refuse to admit it?

I have thus far reasoned exclusively from diluvial action in Massachusetts. But there is evidence that the last deluge rushed from the north over all that part of North America, between Nova Scotia and Lake Huron. Dr. Bigsby has stated facts in the sixth volume of the Geological Transactions, and the Messrs. Lapham, more recently, in the 22d volume of the Am. Jour. of Science, proving the truth of this statement in respect to the country about our western lakes; and Messrs. Jackson and Alger, in their recent, able memoir on the Mineralogy and Geology of Nova Scotia, have drawn the same inference from the present position of erratic bowlders in that country. Do not these facts, in connection with those stated in this Report, render it extremely probable, that over the whole breadth of North America, the current came from the north: although deflected in some places by local causes?

Nor is this all. The facts that have been observed in relation to diluvial action in England, Scotland, Ireland, Sweden, Germany, Russia, and the Northern parts of Asia, seem to justify the inference, that the last deluge in those portions of the globe, came from the north; though modified in its course by local causes.* Hence it would seem that this deluge, in all the northern parts of the globe, had this direction; and may have been produced by the elevation of an extensive portion of the bottom of the Arctic ocean. De La Beche, in his recent able Geological Manual,† seems to regard the 'centre of disturbance' as situated to the north of Europe; and leaves us to infer that diluvial action in America was merely the result of the mighty wave, proceeding from that centre. But so far as I can judge from the accounts which European geologists have given us of diluvial action, in that quarter of the globe, I doubt exceedingly whether it has left traces by any means as striking as in this country. As to grooves and furrows in the rocks, for example, the writer above quoted says, that 'Sir James Hall even considers that a rush over the land (in

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* Mr. J. Phillips infers from recent examination in Yorkshire, England, that the diluvial current there was from the north and northwest. And Mr. Murchisson finds that the direction of the diluvial markings on the rocks in Brora district, Scotland, is uniformly from N. N. W. to S. S. E. *See Philosophical Magazine, Vol. 2, N. Series, pp. 140 and 150.*

† Page 164.

Scotland,) has left traces of its course in the shape of furrows, which the transported mineral substances, moving with great velocity, have cut into the solid rocks beneath.' Such language implies that these traces are by no means common, as in our country. Have we not then reason for supposing that the 'centre of disturbance' might have been situated nearer to this continent than to Europe? Although the general direction of the current on both continents seems to imply that its situation was not far from the north pole.

The recent profound generalizations of Elie de Beaumont, in regard to the elevation of mountain chains, at various epochs, seem to have rendered it all but certain, that the deluge of history was produced by such an event. This is the opinion of Beaumont. The elevation of a chain of mountains from the ocean's bed, 'would produce effects in countries remote from the spot,' says he, 'similar to the sudden and transient deluge of which we find traces, and of a uniform date, in the archives of all people.'—'If that historical event,' he adds, 'be nothing else but the latest of the revolutions on the earth's surface, it will be natural to inquire, what chain of mountains was elevated at the same date; and possibly it will reach the case to remark, that the chain of the Andes, whose breathing volcanoes are yet generally active, forms a ridge the most extended, the most decided, and the least changed from the actual external configuration of the terrestrial globe.'* If it be true, however, that the diluvium, which I have described, received its present form and position from the historical deluge; and if the direction of the current in all northern countries was from the north; it is difficult to conceive how either the flux or reflux of the ocean, produced by the elevation of the Andes, could have been in that direction. But the history of Iceland proves, that mountains have been elevated in the northern part of our globe by internal forces, within a comparatively recent period: and this circumstance takes away all improbabilities from the supposition that the centre of disturbance was there at the time of the Mosaic deluge. And is not this opinion strengthened by the discovery of the antediluvian elephant, incased in ice, on the shores of Kamtschatka: and of the tiger in the frozen gravel of the same regions; showing that the waters of the Arctic ocean were poured over that country when these animals were enveloped, producing such a change of temperature, that not until the present century, did the ice melt away enough to disclose their remains.

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* Recherches sur quelques-unes Des Revolutions de la Surface du Globe.—Paris 1830.

Mounds in the Western States.

Before concluding the subjects of alluvium and diluvium, I hope I shall be excused for making a short digression. Although it may seem arrogant in one who has never personally inspected the celebrated mounds of our western states, so universally regarded as the work of man, I hesitate not to advance the opinion with great confidence, that they are almost universally the results of diluvial and fluviatile action. To say nothing of their great number and size, which would render their construction a work of ages for all the millions of the globe, there is one fact stated by an acute writer, that must put the question at rest. He says that he 'had never examined one that was not composed of different strata of earth, invariably lying horizontally to the very edge of the mound.'* Now I take it upon me to say, that it is altogether beyond the art of man to pile up large hills of loam, sand, clay, &c. so as to exhibit the stratified structure here spoken of. Let any man but examine the alluvial or tertiary banks of a river having a stratified structure, and he will at once see that human skill can never imitate this work of water. These mounds, therefore, scattered as they are in immense numbers over the western regions, are the work of God and not of man. They were either piled up by diluval action, or the they are remnants of tertiary formations, that have been mostly removed by rains, land floods, and deluges. We have an abundance of just such mounds in New England, which need only a lively fancy to convert into the products of a once mighty and highly civilized people. The south-eastern part of Massachusetts abounds with hills of this description. In the more central parts of the State they are less common. Yet the traveller will frequently meet with elevations of this kind, which viewed in certain directions are regular cones. Such examples may be seen in Franklin and its vicinity. One occurs a mile or two east of the meeting house in Enfield, on the banks of a small stream: and a similar one may be seen in Deerfield, at the foot of Long Hill, two miles south of the village. In making the road, one half of this mound has been dug away, so as to exhibit its horizontal strata. Others may be seen on the stage road between Belchertown and Ware. That such elevations should have been selected, both in New England and at the west, for the habitations, the forts, and the burying places of the aboriginals, is just what we might expect. And this circumstance has doubtless given rise to the idea that these mounds are artificial. Nor will the belief that we can point to monuments of human skill more ancient than the pyramids of Egypt be likely to receive a very strict scrutiny, or be easily abandoned.

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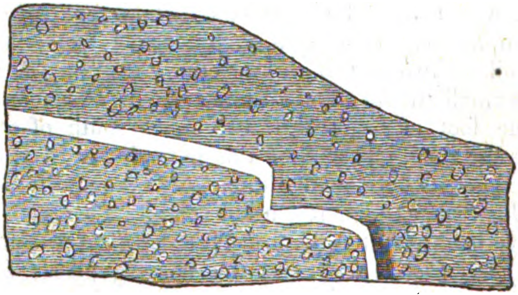
* Illinois Magazine Vol. I. p. 252.

Stratification of Diluvium.

Though in this formation the materials be confusedly mingled together, yet it must not be understood that it is entirely homogeneous and destitute of stratification. In all deluges, during their swelling and subsiding, there will be more or less of flux and reflux, of violence and quiescence in the waters, and of course the materials deposited will be sometimes finer than at others. This will lay the foundation for stratification; and indeed, most diluvium exhibits as much of it as those coarse consolidated conglomerates in the older rocks, which sometimes alternate with sandstones and even shales. This resemblance in their character is interesting, because it proves an identity of causes in their production. It is not very common, however, to see in our diluvium a very sudden change from coarse to fine materials. I was hence interested in the section of a diluvial hill in Schoodac, N. York, through which (as laid bare by excavating the road,) there extended a stratum of loam, the mass of the hill being made up of coarse gravel. This stratum was only a foot thick at its upper extremity, and dipped a few degrees towards the north. Near its lower extremity, it had been bent downwards nearly at right angles, as shown below; and the upright portions were drawn out, as if in a plastic state when the lower part slid downwards. For to suppose that the hill had thus sunk, will satisfactorily explain the case; and as such an occurrence would be more likely to take place when the whole mass was saturated with water, we should expect that the loam would be in a plastic state. Very probably the inclined position of the whole stratum resulted from a slipping down of that part of the hill which embraced it.



Diluvial Bank: Schoodac, N. Y.

Mineral Contents.

Since diluvium embraces portions of every rock that rises to the surface, we might expect to find in it specimens of all the minerals which the rocks in place contain. And it would be easy to enumerate a very extensive list, in this formation, in Massachusetts. But this could be of no use: and I shall only mention the few which are of special interest.

The most important of these is native gold, which exists in diluvium in Somerset, Vt. The soil from which I saw it washed, was taken only about a foot below the surface, and consisted of loam, or of sand and clay, containing vegetable matter. Deeper in the ground the materials are coarse. But to what depth the gold extends, has not been ascertained. As I have given an extended description of the features of this gold region in the first part of my Report, and shall hereafter more particularly describe its mode of occurrence in the talcose slate, from which it has been washed, I need not dwell upon the subject here.

A few years since, a mass of native copper was fonnd in the diluvium of Whately, weighing 17 ounces avoirdupois. Its shape was irregular, and it was partially coated with the green carbonate of copper. There can be little doubt but this proceeded from the new red sandstone or the greenstone; although in Massachusetts, this mineral has not been found in either of these rocks.

Dr. Samuel L. Dana informs me, that recently a small mass of lamellar sulphate of baryta, containing some specks of galena, and with some quartz and feldspar attached to it, was discovered in diluvial gravel in Waltham. This fact is interesting, because, with this exception, no baryta has been discovered in that vicinity. Near the spot, however, rolled masses of quartz have been dug up, containing galena. These facts certainly indicate a vein of these minerals in the vicinity: and I venture to predict, that if ever it is brought to light, it will be found north of the spot where the diluvial fragments occur.

Organic Remains.

I know of no instance in which organic remains of any interest have been found in our diluvium, with the exception, perhaps, of several species of recent shells in two or three places. The Messrs. Danas state, that in Cambridge, a common species of Mya was found, forming a stratum of three or four inches thick, in the side of a hill; also strata of Mya, Mytilus, and Ostrea, several inches thick, and from five to ten feet below the surface, at Lechmere Point; also fragments of Mya, 40 feet below the surface, at Jamaica Plains, in Roxbury, and the fragment of a similar shell 107 feet deep in the soil at Fort Strong on Dorchester Heights. Similar beds of shells are also found on Nantucket; such as Natica, Pyrula, Venus, Crepidula, Solen, Pecten, Arca, &c. as will be more particularly described when I treat of Plastic

Clay. I am not certain that in any of these cases the shells occur in diluvium; though I regard that as the most probable supposition.

3. TERTIARY FORMATIONS.

For a long time these formations were confounded with alluvium and diluvium; but they are clearly distinguished from both, by the much finer state of most of the materials that compose them; by the greater regularity of their stratification, by their relatively inferior position, and by containing peculiar organic remains. As appears from the Map attached to the recent geological work of Mr. Lyell,* tertiary strata occupy more than half of the surface of Europe; yet geologists had paid very little attention to them till the publication of the work of Cuvier and Brongniart, on the Paris Basin, in 1811. In our country, although these formations occupy a vast extent of surface, particularly in the southern States; embracing that broad tract along the coast marked on Mr. Maclure's Map as alluvial; yet have they received but very little elucidation. Messrs. Morton, Vanuxem, and Conrad, have, however, recently devoted themselves successfully to this subject.

After the tertiary beds around Paris and London had been described, it seemed for a long time to be taken for granted, that tertiary strata all over the world must be identical with these: as if those spots contained the types of the whole globe. But geologists now find that no formations are more independent than the tertiary; and that it is very difficult to ascertain a precise identity of origin of any two basins, even when near to one another; and as to those that are widely separated, it is no easy matter to determine whether they were deposited during the same geological epoch.

I shall describe the tertiary rocks of Massachusetts under two divisions: 1. The most recent tertiary; and 2. the Plastic Clay. These are distinguished from each other by their mineralogical characters, their organic remains, and the different position of their strata.

The most recent Tertiary.

The most extensive deposites of the beds of this class, are in the valley of the Connecticut; where they are marked on the Map. They occur also, in small patches in many other places in the State: but they have been marked on the Map in no other place, except in Cambridge and Charlestown. The great resemblance in the mineralogical characters of these beds all over the State, their horizontal position, and the almost entire absence of organic remains in them, so far as they have been examined, have made it impossible to describe them as distinct deposites; though I have little doubt, that many of them, at least, are such. Yet probably they do not differ much in age. But I leave to future observers to settle what I have no means of deciding.

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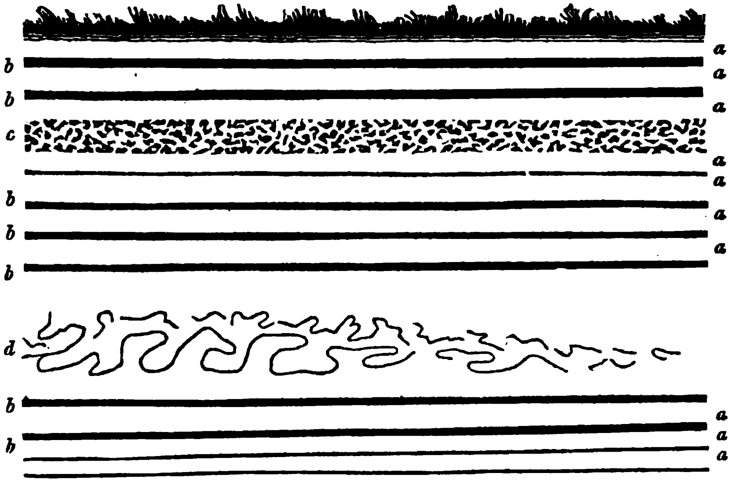
* Principles of Geology, &c. by Charles Lyell, Vol. 2. London, 1832.

These newest tertiary strata consist of horizontal alternating layers of white siliceous sand and blue plastic clay. Along the Connecticut, the sand occupies the highest place in the series; and covers most of the surface. Its upper portion is disturbed and piled up irregularly by diluvial action; and sometimes mixed with transported gravel. But where the streams have worn passages from 10 to 15 feet deep, they have almost uniformly disclosed the stratum of clay. And not unfrequently tracts of considerable extent are entirely swept of sand, whereby the soil is rendered highly argillaceous. Generally the beds of sand and gravel appear to be several feet thick; but sometimes I have found numerous alternations in the height of a few feet, or even a few inches—some of the layers not being more than half an inch thick. Some years since, I obtained the following rough sketch of a cliff, a few feet in height, in Deerfield; the face of which had recently been laid bare by the sliding away of its outer portion. The beds *a*, *a*, &c. *b*, *b*, &c. *c*, and *d*, represent different horizontal layers of sand and clay; the former becoming often very fine, and the latter sometimes approaching to loam. Some of the layers of clay were not more than half an inch thick; and these in general, with the interstratified sand beds, appeared as if deposited from water perfectly at rest. But the stratum *c*, presented a most remarkable exception. It was composed of angular and rounded pieces of clay, mixed with sand, and obviously resulted from the breaking up of several thin beds of clay and sand, by some unusual agitation of the waters. The stratum *d*, was still more remarkable. It consisted of sand and two layers of clay; the latter being very irregularly bent, as if, when in a plastic state, it had been acted on by opposing lateral forces.

If I mistake not, this section throws light upon the manner in which some of the disturbances in the older rocks may have been produced. Let the stratum *c*, be only consolidated by heat, or otherwise, and we have a perfect conglomerated sandstone, or graywacke. Let the stratum *d*, be not only consolidated, but partially melted, so as to become in a good degree crystalline; and we have that variety of mica slate or quartz rock, in which the planes of stratification do not correspond with the contorted schistose layers. The undisturbed beds of sand, by the same igneous action, might be converted into quartz rock, or mica slate; and the interlaminated layers of clay, into argillaceous slate, or hornblende schist, or both. Thus from this thin tertiary formation, might result hornblende slate, mica slate, quartz rock, argillaceous slate, conglomerated graywacke, and sandstone: and these might present much of the regularity and irregularity peculiar to each rock. And to accomplish this, and also to give the strata an inclined position, we have only to suppose the same volcanic agency to be exerted, which we know has been a thousand times employed in the elevation of the strata, and in the protrusion of the unstratified rocks. Indeed, from some of the sections and descriptions given in the third volume of Lyell's Geology,[*] of the induration of the Newer Pliocene strata (newer tertiary) in the isle of Cyclops, near mount Etna, it appears that a considerable part of this transformation has there been accomplished.



Section of a Cliff of Tertiary Clay and Sand: Deerfield.

The preceding section was obtained on the side of a gully, few rods west of the stage road at Long Hill, two miles south of Deerfield north village. The last year, I obtained the following sketch from a clay pit, recently opened, a few rods east of the Academy, in Deerfield. The contorted portion of the wall of the pit, was about three feet in perpendicular thickness; and above and below, (as shown on the sketch,) the layers of clay were perfectly regular and horizontal. This proves beyond all question, that the disturbance must have taken place during the period of the deposition of the clay; and that the cause must have been a transient one. A few rods farther to the east, as we pass up a hill, a similar disturbance of the layers of clay appears at a higher level, and of several rods in length; proving that the cause, whatit might be, recurred at intervals. This case differs from the one first described, in there being no interstratified layers of sand, as are shown in the preceding sketch.

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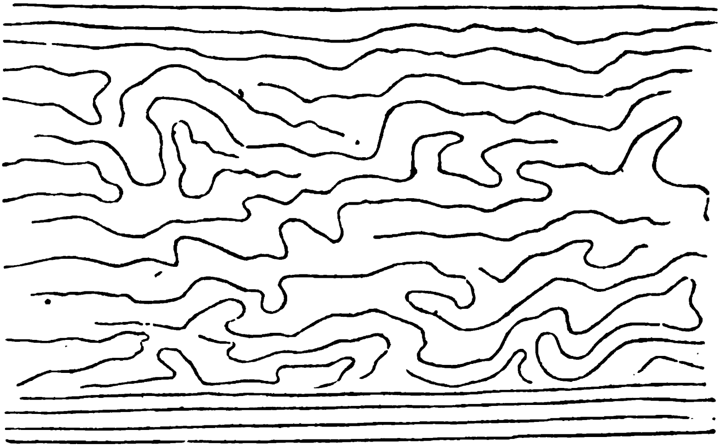
[*] Page 80.



Contortions in the Clay Beds: Deerfield.

Disturbances similar to the above are figured in the recent work on geology by Mr. Lyell,* as occurring in the crag of England, which belongs to his older pliocene strata. His sections exhibit, however, much less of flexure than the above. His explanation of the mode in which they were produced, by referring them to the action of irregular and counter tides and currents, has a less felicitous application, therefore, to the preceding cases, than to those in England; although I doubt not essentially correct as to both.

Position and thickness of the Strata.

There is no evidence, that I have ever been able to find, to prove that these tertiary strata have been disturbed since their original deposition. Nevertheless, the layers, or strata, are not exactly horizontal. Where the surface beneath is slightly undulating, the laminæ of clay are conformed to the irregularity. This produces a dip sometimes of two or three, or even five degrees, and in one or two cases (the east side of north Sugar Loaf mountain, in Deerfield, and the hill a mile south of Brattleborough east village, for example) it falls but little short of 10°. A less dip may be seen in the clay hill east of Deerfield Academy: and in the east part of Hadley, on the middle road to Amherst, the laminæ conform to the gentle swells and depressions of the ground. At the base of steep hills, however, the clay beds are generally horizontal; because, as I suppose, the declivity was too steep to permit of these depositions in a comformable manner. This fact, and the circumstance that in those cases where there is a slight inclination of the clay bed, the dip follows no general law, but conforms to the surface, has led me to conclude that this tertiary formation remains as it was originally deposited. I mean that the few cases of dip which exist, do not prove any disturbing force acting subsequently to the deposition of the formation. And I think we have in these cases, the maximum of inclination in a sedimentary deposite of of clay and sand, formed in still water. For since hills of every degree of inclination must have existed in the bottom of lakes, ponds, or the ocean, in which this formation was deposited, the layers of sand and gravel would have remained in a comformable position on every slope that was not so steep as to cause the materials to slide down. I think that in no case the inclination is more than 10°; although I have not applied the clinometer.

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* Principles of Geology, Vol. III, p. 174.

The measurement of a base line for a trigonometrical survey of the State, in the valley of the Connecticut, by Col. Stevens, during the year 1831, has furnished another proof that this tertiary formation has not been disturbed since its deposition. For the tracery of that line, (nearly eight miles long,) was made upon this formation; and the two extremities were found to correspond in their level within three feet.

Mr. Smith, in his account of the Connecticut river valley in volume 22d of the American Journal of Science, states that the greatest elevation of clay beds along Enfield Falls, is about fifty feet above the present surface of the river; and this, if I understand him, exceeds the general thickness of the clay beds in that region. But as we descend into the basin in which the village of Deerfield is situated, the clay, without any alternation of sand, is exposed not less than 60 feet in depth; and still the bottom is not seen. A little east of the Academy, in the same town, the layers of clay rise 30 or 40 feet above the plain, and at the same place have been penetrated at the foot of the hill, 25 feet, without reaching the bottom: so that in this valley, this single bed of clay, cannot be less than 60 or 70 feet thick; and it may be much more. The stratum of sand above the clay is so much mixed in its upper part with diluvium, that I can form but a very vague idea of its thickness. It can, however, hardly be less than 15 or 20 feet.

I have no evidence that a stratum of sand is found beneath the clay in the Connecticut valley; though, as already mentioned, there are sometimes numerous alternations of the sand and gravel in narrow strata, near the line of junction. Mr. Smith also states, that in excavating the canal at Enfield Falls, the clay beds were entirely cut through: and that between the beds and the new red sandstone, was found a confused mixture of rounded masses of sandstone, greenstone, granite, and other primitive rocks, mixed with red clay from 4 to 20 feet thick. This is an interesting fact; because it proves that in the interval between the deposition of the sandstone and the tertiary formation under consideration, fluviatile and diluvial currents, similar to those that have since existed, must have been in operation.

The surface of the tertiary formation in the vicinity of Boston has been so much acted upon by diluvial currents, that as already remarked, I have been at a loss whether to describe it as tertiary or diluvial. But there is no doubt, I believe, that genuine clay beds, or layers of clay, do exist not far beneath the surface. This clay is represented by the well diggers as extremely hard; and underneath it, are layers of sand and gravel. It is from 70 to 120 feet thick; and when perforated, water rushes upwards with great violence. The only genus of organic remains found in the tertiary of the Connecticut valley, I have discovered also in the clay of Charlestown; unless I have greatly misapprehended its character. But the same genus occurs also in the clay beds of Nantucket; which I have been inclined to consider as belonging to the Plastic Clay; so that this relic does not seem to afford much aid in determining the relative antiquity of these several beds.

As to other limited patches of tertiary in the State,(excepting the Plastic Clay, which occupies its southeastern part,) I know almost nothing. I have seen only pits opened in them occasionally, for the purpose of making brick. But although the clay appears to be mineralogically identical with that in the Connecticut valley, yet I have met in it with no sort of organic relic. These beds must vary in relative level several hundred feet; occupying as they do, the depressions of the surface in the various formations. This fact precludes the idea of their having been deposited by the same body of waters, unless they constituted an ocean deep enough to cover the whole surface of the State. And such a submersion is rendered improbable by the horizontal position of the layers of clay; which shows that no elevating force has acted upon the State since their deposition. Their production in different and independent basins of water, such ponds, perhaps, as now exist in Middleborough, Troy, Falmouth, Webster, &c.* —is the more probable hypothesis.

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* The name of the principal pond in this latter place, although not given on the Map, deserves to be mentioned, because it is so laconical and euphonical. It is Chargoggagoggmanchoggagogg.

I call these various deposites the newest tertiary in the State, but my only proof that they are newer than the plastic clay of the southeast part of the State is, that the strata of the latter, at least, at Martha's Vineyard, are inclined at a high angle; while those of the former are horizontal. And we know that the older strata are generally, though not always, more inclined than the newer. I know of no place where these two series of strata are in contact, so that their true relative position may be seen.

Mineral Contents.

I place in this formation the extensive beds of the hydrate of iron, (*Limonite*, Beudant; *Prismatic Iron Ore*, Mohs; *Brown Oxide of Iron*, Cleaveland,) which occur in the limestone valleys of Berkshire county; and in connection with the same range of limestone and mica slate, in Vermont and Connecticut. I am aware that in doing this, I deviate from the opinion of several geologists, who have examined these beds, and seem inclined to regard them as belonging to the mica slate or gneiss.* But I could not find the slightest evidence, at any bed of this ore which I visited, that it is interposed between layers of mica slate, gneiss, or any other solid rock. It is, however, usually associated with more or less of clay; and, therefore, I regard it as belonging to a tertiary formation. Generally the bed is covered by nothing but diluvium; and diluvial action seems sometimes to have disturbed the ore to a considerable depth, so that my doubt has been, whether it ought not to be placed even as high as diluvium, rather than whether it belongs to the primitive rocks. Professor Silliman does, indeed, speak of a ledge of gneiss, as being brought to view by the excavation at Kent, in Connecticut, in the upper part of the mine; and he considers this the roof of 'the vast bed of clay, which forms the immediate enveloping matter of the ore.' Although I have not visited the ore beds in Kent, I must be permitted to doubt whether there be not a deception in respect to this point. For the occurrence of a 'vast bed of clay,' unconsolidated, in gneiss or mica slate, is such a perfect anomaly in geology, that it cannot be admitted without the strongest evidence. And when I find these ore beds at Salisbury, West Stockbridge, Richmond, and Lenox, most obviously lying above the primary rocks, I cannot but suspect that this is the case also at Kent: though I would not close my eyes against evidence to the contrary.

If it be admitted that this hydrate of iron belongs to a tertiary formation, it by no means follows that its deposition was isochronous with that of the newest tertiary in the valley of the Connecticut: and the occurrence in the former, of so much iron, while it is very sparingly disseminated in the latter, is a presumptive argument against their production in the same menstruum.

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* Am. Journal of Science, Vol. II. pp. 213 and 216: also Vol. VIII. p. 30.

The principal beds of the hydrate of iron in Berkshire county, are found in West Stockbridge, Richmond, and Lenox. Out of Massachusetts, the beds at Bennington, Vt. and at Salisbury and at Kent, Ct. are best known. The most common varieties are the brown hematite, and compact brown oxide, though the ochrey brown oxide is very common, as well as the argillaceous oxide. The hematite is often beautifully mamillary and stalactical. (Nos. 53, 54, 55.)

No one looks at the stalactical specimens of this ore, without inquiring at once, whether heat must not have been concerned in its production. For the specimens exceedingly resemble certain stalactical varieties of lava, or the products of a powerful iron furnace. And in their natural position, the stalactites usually hang in a perpendicular position, as they would do if formed by the dripping of tenacious melted matter. But after all, there seem to be insuperable difficulties in admitting the igneous origin of hematite. For how could heat have operated powerfully enough upon the hematite to melt it, without melting, or at least indurating, the clay in which it is enveloped? Again, the occurrence of this ore in calcareous spar and quartz, (which are usually of aqueous origin,) shows that it may be produced from water. It is likewise now admitted, I believe, by the ablest mineralogists,* that argillaceous oxide of iron and bog, are only impure varieties of hydrate of iron. And the bog ore is daily forming before our eyes by aqueous deposition, and some of it is in fact the same as the compact brown oxide. Only admit, then, that circumstances were favorable to crystallization, when the hematite was in a state of solution in the water percolating through clay, and may we not conceive how that ore was produced?

The oxide of manganese, sometimes delicately radiated, and sometimes investing the hematite occurs probably at all the beds of hydrate of iron that have been mentioned. I noticed it particularly at the bed in West Stockbridge; and it is well known that it did exist in Bennington, Vt. in the same connection, in large quantity.

Associated with the hydrate of iron in Richmond, in a bed owned by Mr. Gates, there has been found a hydrate of alumina, (alumina, 64. 8, water, 34. 7,) which Professor Torrey has named Gibbsite, in honor of Col. George Gibbs, one of the earliest cultivators, and most munificent patrons of mineralogy in our country. It occurs mamillary and stalactical, of a white color. It may be obtained there abundantly: and a single specimen has been found in Lenox. (No. 61.)

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*Beudant's Mineralogie, Vol. II. p. 702: Dictionnaire Classique D' Histoire Naturelle, Art. Fer Hydrate or Hydroxide: also Mohs Mineralogy, Vol. II. p. 410.

The nodular argillaceous oxide of iron and yellow ochre occur occasionally in the tertiary region around Boston, particularly in Charlestown and Cambridge.

Concretionary Carbonate of Lime.

In the clay beds of the Connecticut valley, a curious concretion occurs, which has received the name of claystone, from its resemblance to indurated clay, that has been rounded by the action of water. Indeed, I did not till recently suspect the presence of carbonate of lime: but the application of an acid produces considerable effervescence. The general shape of these concretions is that of an oblate spheroid, sometimes so flattened as to become lenticular, and sometimes nearly spherical. The spheroids are usually joined together with considerable strength. They vary in size from two inches, down to that of the smallest pigeon shot, and some of these smallest are so numerously strung together, as to become decidedly botryoidal. In other instances, the spheroids are so intimately blended, that there are no interstices between them; and only slight convexities are exhibited, in relief, on the surface. Not unfrequently that surface is studded with minute spheroids, not larger than the head of a pin. Sometimes the concretion is not spheroidal, but simply an irregular plate, often several inches across. In no case does the thickness of these plates, or a congeries of the spheroids, exceed that of a single layer of the clay, which is rarely more than half an inch.

On breaking these concretions they are found to be perfectly solid and compact; exhibiting in no instance the slightest marks of a concentric structure, such as we see in the oolite. Nor could I bring to light a concentric arrangement of the materials by applying the heat of a blow pipe, even till the surface was fused. Generally, however, the heat of a lamp alone will cause them to burst asunder with considerable force. The mass is obviously composed of carbonate of lime mixed with clay, such as that in which they are found, consisting of alumina and fine sand, with occasional fine scales of mica. The hardness of the concretion is about the same as the common impure compact limestones. It does not constitute any considerable part of the stratum in which it is found. I have observed it in Amherst, Hadley, South Hadley Canal, Chicopee in Springfield, Greenfield, &c.; also in the clay beds along the river Hudson, near Albany.

I have been thus particular in this description, because I have met with but one account of any similar production in any tertiary strata. It is obviously an example of the solid concretionary structure, and must have resulted from chemical agencies. But are concretions the result of crystallographical laws? If so, why are not crystals produced? It seems to me that philosophy is yet in the dark on this subject. At first it occurred to me that these concretions were the oolite in a forming state; and that the consolidation of the clay would develope a concentric structure. But my failure to bring this to light by the application of heat, convinced me that the opinion is untenable.

The single account of similar concretions referred to above, is that of Cuvier and Brongniart, in their description of the Paris Basin. 'We find,' say they, 'towards the surface of that bed of clay, (the Plastic Clay,) masses as large as the head, though often much smaller, of nearly compact limestone, or made up of small compact nodules, aggregated together as if by concretion. These masses of limestone have their edges blunted and their angles both salient and reentrant rounded, as if they had been plunged into a liquid solvent.' *

Quite recently I have found in the gray argillaceous sandstone at Sunderland cave, in Mount Toby, numerous reniform concretions, very much resembling those above described. And I find that they effervesce with acids, which proves their identity. Some of them so exactly resemble *Unios* in form, that I at first suspected them to be petrifactions. But a careful examination satisfies me that the similarity is accidental. This fact shows us that the same causes operated when this sandstone (a variety of the new sandstone) was deposited, as when the newest tertiary was formed. A fact analogous to the one just stated is mentioned by Dr. Macculloch. 'In the argillaceous limestones, as well as in the accompanying sandstones,' says he, 'highly flattened spheroids of large dimensions are found attached in pairs by a cylindrical stem, and imbedded in the surrounding rock.' †

Organic Remains.

The newest tertiary in Massachusetts, judging from the examation which I have made of it, is remarkably wanting in organic remains. Indeed, I have found but a single genus, and even this is in so imperfect a state that I have been unable to ascertain its nature. It was probably some kind of animal: and some of the specimens bear a considerable resemblance to the *Ovulites margantula* of Goldfuss' *Petrifacta:* but I have never seen in it any thing of the 'poris minutissimis ad superficiem amussim depositis,' which he represents as belonging to that petrifaction. Other specimens resemble the *Scyphia* of the same author, but the 'e fibris reticulatis' is wanting. It is doubtful whether the sketches which

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* Recherches sur les Ossemens Fossiles, par Cuvier, Tome 2. p. 341. Paris, 1825.

† System of Geology, Vol. I. p. 179.

I have given of this relic, (Plate XI. Figs. 18, 19, 20, and 21,) represent any thing more than fragments of it, worn into an ovoid shape. Fig. 22, however, does certainly represent one extremity of the animal unaltered: for it is still partly enveloped in loam, and therefore has never been worn. But the fragments are sometimes cylindrical, varying in size from a quarter of an inch to more than an inch in diameter. These usually perforate the strata of clay perpendicularly; that is, at right angles to the layers; and they are sometimes several inches long. The extremities, however, I apprehend are always similar to Fig. 22. The most decisive evidence of organic structure which these remains exhibit, is a longitudinal perforation of the size of a knitting needle. They are, it is true, easily divisible transversely: but this seems to depend upon the laminated structure of the clay that chiefly composes them, and not upon the structure of the animal: for the dividing plane conforms in all cases exactly to the layers of the clay. Since clay forms the principal mineralizer, the outer circumference of these cylindrical and ovoid relics, is often very indefinite: and where exposed to rains, they are entirely washed away. Along the central part, however, hydrate of iron seems to have considerably indurated the clay; and, indeed, this iron often pervades the whole mass; giving it a rusty aspect, and hardness sufficient to resist the action of rains. In such cases the relics often stand out in relief upon the surface of the clay, which has been worn away around them.

These remains I have found only in clay or loam. I have met with them in three places in Deerfield, viz. a few rods east of the Academy; near the top of Bar's Long Hill; and on the east side of North Sugar Loaf. They are found also in Greenfield, on Green River, southwest of the village: also in South Hadley, at the Canal Falls; and 100 rods south of them. I have found them likewise in Charlestown, in clay; and also on Nantucket in a stratum of ferruginous sand. Among the specimens deposited in the collection, (Nos. 47 to 52,) I apprehend several species may be made out.

Theoretical Considerations.

That these tertiary beds were deposited from a mechanical suspension of their materials in water, can admit of no question. But was it from salt water or fresh? On this question the only organic relic that has been found in these beds, throws no light; because its nature is not understood. Still, I think we have some grounds for forming an opinion in this case. For the horizontal position of the laminæ of clay in this formation, shows that no change of consequence has taken place in the level of the surface, since they were deposited. Hence, unless the level of the sea has sunk greatly since that period, it could not then have covered the regions occupied by these beds. They were probably, therefore, deposited from fresh water lakes and ponds. In the valley of the Connecticut, that river must have flowed through the lake; or rather, an expansion of the stream formed the lake. The gradual sinking of its bed at length brought the tertiatry strata *sub luce*.

The probable absence of marine relics from these beds, is another argument in favor of this hypothesis; and it would be complete, were the fact certainly established.

In respect to the tertiary strata in Charlestown and Cambridge, their low level, and vicinity to the ocean, lead to the supposition that they were deposited from salt water, by a process similar to that which is now going on in the salt marshes in their vicinity.

Plastic Clay.

A cursory examination of the strata of Martha's Vineyard, ten years ago, led me to adopt the opinion that they correspond essentially with the Plastic Clay Formation of Europe: and I gave an account of them under that name in the American Journal of Science. Every subsequent examination has confirmed the opinion then formed. And I have ascertained, also, that the same formation exists in several places on the continent, in the southeastern part of the State; and likewise on Nantucket. Wherever in that region sands prevail extensively, I have reason to suppose this formation exists; though I am by no means sure but some of these sands may belong to a newer formation. At some places, however, variegated clays underlie the sand, and fossils are found corresponding with those on the Vineyard; and such strata I cannot but regard as identical with the plastic clay of that island. It is on the Vineyard, however, that this formation is most fully exhibited; and I shall first describe the strata which exist there, and compare them with the plastic clay in Europe.

There are but two places on the Vineyard where I have found the strata laid bare to any considerable extent and depth. The one is a cliff in the southeast part of Chilmark, laid bare by the action of the ocean, and slowly wearing away from year to year. The other is Gay Head; which is an elevated promontory from 150 to 200 feet high, forming the western point of the island, still owned and inhabited by the mixed descendants of the aboriginees. This spot is the most interesting and instructive. The very heart of the formation appears to be here exposed. It consists in general of interstratified, inclined layers of gravel, sands, variegated clays, iron ore, and lignite.

Mineralogical Characters.

1. *Clays.* These greatly predominate in the cliffs at Gay Head; and by the vividness of their colors, attract the attention of the most careless observer. Their variety in this respect is very great; but the following predominate. 1. *White Pipe Clay.* This generally contains small plates of silvery mica, and obviously resulted from the decomposition of granite. 2. *Blood Red Clay.* This is doubtless colored by the red oxide of iron, and forms an important part of the cliff. 3. *Red and White Clay.* This is a mixture of the two first varieties, and the two colors being often fantastically arranged, give to the cliffs a gay appearance. 4. *Bluish Gray Plastic Clay.* This is the most compact of all the varieties. It often becomes nearly black, where it lies contiguous to the beds of lignite; and when in contact with the white and red varieties, a mixture of them all results.

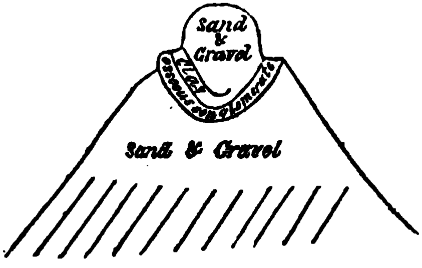
2. *Sands.* Next to the clays the sands are most abundant: though at Gay Head they do not exist in great quantity. They are there sometimes interstratified with the clays; and indeed, some varieties of the clay contain so large a proportion of sand, that it is not easy to determine whether they should be denominated clays or sands. Of the sands I have noticed the following varieties. 1. *White Siliceous Sand;* generally fine, but sometimes coarse. This is the variety which is spread over almost every part of the southeastern district of New England; generally, however, mixed with pebbles and bowlders, and constituting diluvium. It may be seen in its greatest purity near the extremity of Cape Cod, where it is of snowy whiteness; and also on Nantucket. On the Vineyard it is generally yellowish from the oxide of iron. 2. The same sand, cemented by the yellow hydrate of iron, so as to form a loose sandstone. It is easily crumbled down, however, and is not abundant. I have noticed it at Gay Head; in the cliff in the eastern part of Chilmark; and on Nantucket, a mile northwest of the town. 3. *White Micaceous Sand.* This is in fact a mixture of silex, mica, and white clay; the latter ingredient not being present in sufficient quantity to hold the particles together. Not abundant. 4. *Green sand;* of a distinct but dull green color. It is sometimes so mixed with clay, as to form a compact mass, even when dry. It is interstratified with the red and white clays at Gay Head, where alone have I noticed it. It is this stratum that contains the greatest variety of the organic remains at Gay Head; and on this account, its exact geological position is important to be known. It has been already remarked, that the strata in this cliff dip nearly north, or rather a little inclining to the northeast, at an angle varying between 20° and 45°. Now the green sand lies near the northern extremity of the cliff, though it is succeeded by other strata of the same clays that con-

stitute the principal part of the cliff. Hence we may infer that the green sand lies near the upper part of this formation, so far as we can judge from this cliff: though as the horizontal distance from one extremity of the cliff to the other, across the strata, is not more than 80 rods, and this promontory appears to be merely an insulated remnant of the formation, we cannot be sure that the position of the green sand is near the upper part of the original formation. It ought here, also, to be remarked, that the organic remains found in this sand, such as crabs, shells and alcyonia, are rolled; and were obviously the ruins of some former rock. Indeed, nodules of a peculiar conglomerate are found in this sand, sometimes containing organic remains.

3. *Lignite.* As this constitutes beds sometimes as much as five feet thick, it seems deserving of a description among the strata, rather than as an imbedded mineral. It alternates with the clays, principally with the blue variety, with which it is often intimately mixed. More commonly it is comminuted and forms a dark mass, somewhat resembling peat. But sometimes the woody fibre is very distinct. In short, it seems like a deposite of peat, through which logs are interspersed. It burns but poorly. The principal beds lie not far from the middle of the cliff, and have a dip from 40° to 50° north.

4. *Conglomerates.* The most interesting of these is the *osseous conglomerate;* which consists of rounded quartz pebbles, rarely more than an inch in diameter, with a cement of animal matter, (?) clay, iron, and sometimes a minute portion of carbonate of lime. It abounds in fragments, mostly rolled, of the bones and teeth of animals; some of them very large. It is sometimes as hard, and broken with as much difficulty, as graywacke: but in other places the coherence in not strong.

The strata of this conglomerate are from one to three or four feet thick, and for some time I supposed that it had been deposited in a small basin on the edges of the elevated strata of clay and sand; for I found the bed, which I first discovered, to lie as in the following sketch.



The conglomerate occupies a projecting point of the cliff, covered at the top, and for a considerable extent upon its sides, with sand and gravel, and exposed to degradation from winds and rains. The edges of the conglomerate, however, project through the sand at the edge of the cliff, where its curved position is obvious; and on one side a layer of clay appears above the conglomerate. Below these beds the sand conceals the regular strata in the cliff: but the inclined lines beneath the sand and gravel, in the foregoing sketch, show the dip of these strata in the vicinity, wherever they are visible; nor could I doubt but the conglomerate bed is superior to the clay, and a later formation. And I find that in some of the tertiary strata in Europe, above the plastic clay, occur layers of calcareous, ferruginous, and bony breccia; as in the valley of the Danube, described by Mr. Murchisson.* But on further examination, I found in the vicinity of the bed of conglomerate above described, two or three other beds distinctly interstratified with the clay and exhibiting the same dip. This rock does, therefore, form a part of the plastic clay formation; whatever we may think of the case described above. And I cannot find that the like deposite, containing the bones of vertebral animals, occurs in any plastic clay formation described in Europe; although in England, pebble beds alternate irregularly with the sand and clays, but it does not appear that these are consolidated.†

Another variety of conglomerate at Gay Head, consists of pebbles, chiefly quartz, cemented by a great abundance of the hydrate of iron, and often containing hollow nodules of the same. I am not sure that this alternates with the layers of clay and sand. On account of the great quantity of its debris, that has fallen down upon the face of the cliff, I found it difficult to ascertain its true position in regard to the strata of clay and sand. I was not without a strong suspicion, that it might lie in nearly horizontal strata upon the top of plastic clay; nay, I was led to inquire whether it might not be diluvium consolidated by iron.

A third kind of conglomerate has been already alluded to, as existing at this cliff, in rolled masses, a few inches in diameter, in the green sand stratum. It occurs, also, very frequently along the beach; having been probably washed out from the cliff. It is unlike any rock that I ever met with. The nodules are almost if not entirely quartz, and the cement a black compact substance, highly bituminous, and slightly effervescing with acids. It appears like bituminous marlite, finely comminuted. As already mentioned, in one piece I found the remains of a Zoophyte.

At the foot of the cliff, I also found rolled pieces of a yellowish gray rock, hard and compact, approaching hornstone. It appears like argillaceous sandstone, which has been subjected to powerful heat by the proximity of trap, such as occurs at Mount Holyoke, on Connecticut river; but I have met with the like rock nowhere else in the State. (No. 81.)

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* Philosophical Magazine, March, 1831, Vol. IX. p. 218.

† De la Beche's Manual, p. 235. 2d Ed. London, 1832.

In a kind of ferruginous sand in this cliff, I met with one or two small specimens of a rock of oolitic aspect; (No. 80.) which, however, effervesces but feebly with the acids.

Specimens of all the preceding varieties of clay, sand, lignite, and conglomerate, will be found in the collection made for the Government. (Nos. 62 to 81.)

Mineral Contents.

The most interesting and abundant mineral at Gay Head, is the hydrate of iron. The varieties are all argillaceous. The most important are the following.

1. *Nodular.* This is the the most abundant variety, and the nodules vary in size, from that of a walnut to a foot in diameter. Sometimes they are spherical, more frequently ovoid; sometimes ovoid flattened; sometimes composed of concentric layers of the compact oxide and yellow ochre, with a nucleus sometimes of sandstone in the centre, but more frequently hollow. These nodules are generally mixed with a large proportion of coarse sand and gravel, which unitedly form, as already remarked, a conglomerate. The flat nodules are sometimes slaty; and it is on the laminæ of these, that the principal part of the vegetable remains of this formation occur. Sometimes the nodule, when broken open, is seen to envelope a flattened mass of lignite: showing conclusively that the ore originally accumulated around this as a nucleus. (Nos. 121, 122, 123.)

Nodular argillaceous iron ore exists also on Nantucket; as well as in other places on the Vineyard.

2. *Columnar.* Some of the larger nodules mentioned above, being broken open, exhibit, as the result of desiccation, a columnar structure in the interior: the columns varying in diameter from a quarter of an inch, to one, and even two inches; and in length, from half an inch to three inches. The sides are generally unequal in size, and various as to their number. The axis of the column is always parallel, I believe, to the shortest diameter of the nodule. The space between the columns is generally only sufficient to allow of the introduction of the blade of a penknife. In some instances, where a shrinkage has taken place, no regular forms are produced; but the seams run in all directions. I have not observed any case where the seams reach to the surface of the nodule. The outer portion, from half an inch to an inch thick, is compact gray iron stone.

An examination of these nodules, leads one at first almost irresistably to the conclusion, that they must have been once in a melted state, and suddenly cooled at the surface: and the glazed iron-black appearance of their internal surface, tends to confirm this opinion. And yet, I doubt whether it is necessary to evoke the god of fire for a solution of this phenomenon. For the mere desiccation of nodules, containing so much argillaceous matter, will, it seems to me, adequately explain the appearances. Of course the external portion would first part with its moisture and become solid: and as the water gradually escaped subsequently from the interior, the shrinking would produce fissures within; since the already compacted crust would not permit the compression of the whole mass. And as to the shape of the pieces, resulting from the shrinkage, it seems to me that if the nodule be spherical, the fissures will coincide essentially with planes passing through the centre of the sphere. (See No. 126.) But if the sphere be that of a flattened ellipsoid, the greatest shrinkage must take place in the direction of the plane, which coincides with the two longest diameters of the ellipsoid: and, therefore, most of the fissures will be made perpendicular to that plane, so as to produce columnar masses; although there will be a proportionable shrinkage in a direction perpendicular to the plane above mentioned, which will produce at least one termination to the columns: and all the specimens which I have examined, confirm this rationale of the appearances; (See Nos. 124, 125,) as does also the desiccation of clay on the surface of the earth, producing columnar masses, which stand perpendicular to the horizon. I apprehend it will be found, that the true columnar structure exists only in those nodules which are flattened.

The existence, sometimes, of lignite in the centre of these nodules, is another evidence that they never could have been completely fused, since the pieces of wood that were enveloped, must have been entirely destroyed. I am aware that coal is sometimes found in trap rocks, or between the trap and sandstones: but in such cases, I apprehend that the fusion of the trap was only partial as we know to be the case with many lavas.

Further: how could nodules of iron, in the midst of clay and sand beds, have been exposed to a fusible heat, and yet the clays and sands have remained unconsolidated?

3. *Mamillary.* The tubercles of this variety are rarely smaller than a buck shot, or larger than an ounce ball. When broken, they exhibit no appearance of a radiated structure; but are massive, though scales of mica and grains of sand are observable in every part of this ore. (No. 120.) I cannot find that this variety of iron is described in the books on mineralogy. I am informed by Thomas A. Green, Esq. that it exists in much larger quantities

in the cliffs, four miles east of Gay Head, in the west part of Chilmark, a little east of Monimshi Bite, than at Gay Head, where I found it.

4. *Pisiform.* The grains are rarely exactly spherical, and seldom exceed the size of a small pea. Not unfrequently they are distinctly reniform. Color, externally, blackish brown; internally, yellowish brown. Aggregated into irregular masses with clay and gravel. This ore seems sometimes to be the mineralizer of alcyonia, shells, &c. It is not abundant. (No. 119.)

5. *Ochrey Brown Iron Ore.* This occurs mixed sometimes with every variety above described: particularly with the nodular. But it is never seen in large masses.

It is well known that the preceding are valuable ores of iron for smelting; and at Gay Head, particularly, they may be obtained in abundance. That spot is still in possession of the descendants of the Indians of Martha's Vineyard: and it is to be hoped that the Government of the State will take measures to prevent their being defrauded of this ore, which may prove of considerable value.

Radiated Sulphuret of Iron. This is very frequent and beautiful in the osseous conglomerate and blue clay of Gay Head. The nodules are sometimes perfect spheres; from one to three inches in diameter; but generally more or less irregular; the surface often exhibiting one face of numerous cubic crystals; but on breaking the mass, the radiation is obvious. Such, however, is the tendency of this ore to decomposition, that it is difficult to preserve specimens long in a cabinet, unless excluded from the atmosphere. Their decomposition produces of course sulphate of iron, and sulphate of alumina and potash, or alum, which effloresce on the clay. (Nos. 117, 118.)

Sulphate of Lime, or Selenite, exists at the same place in tables and acicular prisms, disseminated in blue clay. (No. 131.)

It is said that amber has been found floating in the ocean near the cliff at Gay Head. I also found it in small quantities, connected with a vegetable relic in iron ore, at the same place. At Nantucket, a mass of light colored amber was found, three or four inches in diameter, which is now in the cabinet of T. A. Greene, Esq. of New Bedford.

Native arsenic is said to have been found at Gay Head; but I saw none.

Organic Remains.

Although these are apparently not as numerous in the plastic clay of Massachusetts, as in that formation in Europe, yet since vegetable and animal relics are rare in New England; and some of those in the plastic clay are not found in the same formation in

Europe, so far as I can ascertain; I have felt not a little interest in those which I have succeeded in obtaining, with much labor and effort. But I regret, that in consequence of my insulated situation in respect to those gentlemen in our country who have paid particular attention to our fossils, and the short time which has elapsed since I discovered those under consideration, which has prevented my consulting more than one or two of these gentlemen, and every European zoologist, I shall not be able to give their generic and specific names as accurately and confidently as I could wish. And the same remarks will apply to all the organic remains which I shall describe in this Report. But as I shall give accurate drawings of the most important species, whenever it is practicable, I trust the deficiency will not be great. I had rather be regarded as very ignorant on this subject, than by substituting conjectures for knowledge, lead others to form false conclusions. It is a subject perhaps the most difficult of all connected with geology; especially in this country, where there is so great a deficiency of good collections of fossil remains.

Fossil Vegetables.

The lignite beds already described, prove the presence of a large quantity of vegetable matter in this formation. This lignite is sometimes ligniform, of a brown color, and distinctly fibrous: sometimes it is hard and brittle; and more commonly, it is friable. I found a mass at the foot of the cliff, which abounded in the impressions of a monocotyledonous plant, bearing the closest resemblance to a Zostera. The mass resembled peat.

But most of the vegetable impressions at this cliff are dicotyledonous; and exist only in slaty argillaceous iron ore. Although these impressions are very distinct, exhibiting the minutest reticulations of the leaf, yet every particle of the vegetable substance is removed. This is true only of those instances where the impressions are leaves. (Plate XI. Figs. 1, 2, and 6.*) The shape of most of these leaves very much resembles that of an Ulmus: but they are wanting in the serratures, which the existing species in this country possess. Fig. 6 has serratures, or rather is crenate, and resembles a Salix. On Fig. 2, may be seen the impressions of pear-shaped seeds.

Figs. 7, 8, and 9, represent different individuals of another variety of vegetable remains, occurring at the same spot, and in the same iron ore. These are not mere impressions; but a scale of carbonaceous matter, mixed with amber, marks the spot where the vegetable was imprisoned. The amber occupies longitudinal ridges, which in the plate are represented by white stripes. It seems to me very obvious, that these remains must be the seed vessels of coniferous plants. The amber shows that they abounded in resin. They resemble unopened flowers of syngenesian plants: but they contain too much resin for these, and have left too much undecomposed matter for so frail a substance. Indeed, although the compound flowers, with their double calyx and strong receptacle, might stand a better chance of being preserved in a fossil state than those of any other kind of plant, yet I am not aware that a flower of any sort has been found in that condition. Near one the specimens of the vegetable under consideration, I observed an ovoid *carpolithes*, about a quarter of an inch long, exhibiting the shell most distinctly, and different from the pear shaped ones just mentioned.

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* All the organic remains that are figured are drawn of the natural size.

Animal Remains.

Vertebral Animals. The bones and teeth of these animals are more numerous at Gay Head than any other organic relics. They are found in the greatest abundance in the osseous conglomerate, already described: but they occur also in the green sand, and in a yellowish sand, associated with the green sand. For the most part, the bones are not mineralized; but frequently they are black when broken; and sometimes they are thoroughly impregnated with iron ore. In general they are much broken and often rolled. In one instance, however, I noticed a succession of large vertebrae, one or two occasionally being absent, for a distance of 10 or 12 feet. Some of these are 9 inches thick, and as much in length. Nos. (104 to 108.) The head in this instance was wanting; and, indeed, nearly all the other bones, except the vertebrae, and short portions of the ribs. (No. 109). But it is improbable that these could have been moved in so connected a state, far from the spot where this huge animal died. In the green and ferruginous sand, vertebrae are found only occasionally; and they are generally much smaller than those in the conglomerate; but they are not rolled.

It ought perhaps to be mentioned, that the largest vertebræ noticed above, occur in the curved bed of conglomerate which lies apparently upon the edges of the other strata. And yet, the conglomerate and the contained bones, interstratified with the clay, cannot be distinguished from those of this upper bed, except that in this single instance the bones are rather larger and less broken and rounded.

Such of these vertebræ, as I thought it would be of any use to have drawn, are exhibited on Plate XII. Figs. 23, 24, 25, and 28. Pieces of the ribs, (some of them 4 or 5 inches in their greatest diameter,) bones of the head, &c. are in general so broken, that a sketch of them would be useless. They will be found among the specimens. All the vertebræ that are drawn, are from the green and ferruginous sand.

All the varieties of teeth that accompany these bones, which I could find, after a protracted search, are exhibited on Plate XI. Figs. 11, 12, 13, 14, 15, and 16. The flat teeth, Figs. 11, 12, and 13, are evidently those of the shark: and Fig. 12, must have belonged to a giant species. Probably also the triangular teeth, Figs. 14 and 15, belong to the shark; and these are more numerous than the others, and rather more broken; though all of them are very often much injured.

Fig. 16 appears to be the fragment of a crocodile's tooth; corresponding with one figured in Cuvier's *Ossemens Fossiles.* It was found in the ferruginous sand, and it differs from all the petrifactions noticed at this cliff, in that it is converted into a substance exactly resembling flint. It is hence not at all probable, that any of the bones that have been described, were connected with this tooth. (No. 103.)

It ought to be noticed, that sometimes masses of lignite are contained in this osseous conglomerate; and that in two instances, I found the bones penetrated by a cylindrical cavity, two or three inches long; pretty obviously the work of some lithodomous shell. (Nos. 112 and 116.)

We ascertain, then, with considerable confidence, the remains of the crocodile and two or three species of sharks in this cliff. None of the vertebræ or other bones which I have described, however, seem to be those of the shark. They bear a much nearer resemblance to those of huge saurian reptiles, which I have examined in the geological collections at New Haven and Philadelphia: one of the vertebræ in particular, appears very much like those of Plesiosaurus. At present I am inclined to believe that the bones at Gay Head belonged to the lizard tribe: though I dare not speak on this point with confidence.

The largest shark's tooth given on the plate, (Plate XI. Fig. 12,) is considerably broken; and, therefore, its exact dimensions cannot be ascertained: but the following measurement certainly does not exceed the truth.

Greatest breadth of the part covered with enamel, measured across the base, - - - - - 2 inches.

The length measured on the enamel of the concave part of the tooth, - - - - - - - 2 inches.

If we estimate the size of the shark to which this tooth belonged, according to the principles adopted by the Count Lacepede and Faujas St. Fond, in the 'Annales de Museum,' its length must have been about 50 feet! Dr. Knox, however, thinks this estimate too high.* But he describes a shark killed on the coast of Africa, as having teeth which measured 1 1-2 inch in the directions mentioned above. Supposing the relative size of the teeth to indicate the relative size of the animals, the fossil shark at Gay Head must have been about 36 feet long! Such was one of the animals that swam in the ancient seas of this latitude! And this result corresponds with the conclusions of European geologists, that the extinct animals were generally much larger than those now existing. The tooth of the crocodile at Gay Head, shows, also, that when this animal swam in the waters of our continent, the climate must have been tropical; a conclusion, which, in respect to Europe, has been well established by a multitude of similar facts.

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* Edingurgh Journal of Science, Vol. 5. p. 16.

If the vertebræ and other bones above described, are those of saurians, the great size of some of them corresponds with the conclusions just stated. In Europe it is well known that these reptiles of a former world, disinterred from the rocks from time to time, were of such gigantic size as almost to stagger belief. Being 60 or 70 feet long, and having jaws with teeth equal in size to the incisors of the rhinoceros, the Iguanodon must, as Mr. Mantell observes, have been 'a colossus in comparison to the pigmy alligators and crocodiles that now inhabit the globe.'* Until farther examination, however, it is only a probable conjecture that the bones at Gay Head belonged to congeneric races.

I have already remarked that I had not met with any account of an osseous conglomerate like that at Gay Head, in any of the European formations of plastic clay. But bones of vertebral animals do occur in one place, at least, in the clay beds of the Paris basin. 'M. Bequerel,' say Cuvier and Brongniart, 'has found in the same bank of clay and lignite, (at Auteuil,) pyrites in great quantities, bones of vertebral animals, whose class has not up to this time, (1825,) been determined,' &c.†

In 1830, Prevost says that 'the remains of reptiles (Crocodiles) and fluviatile shells characterise the plastic clay of the environs of Paris.'‡

In the cliff in the southeast part of Chilmark, I found a fragment of bone, which undoubtedly once belonged to a bird. It was hollow and apparently about as much changed as most of the bones at Gay Head. It was so enveloped in the clay that I could have little suspicion that it was introduced subsequently to the deposition of the clay.

Crustacea. In the green sand at Gay Head we meet with well characterised specimens of the genus Cancer; although they are in general much broken; showing that they originally belonged to a formation which was abraded or destroyed anterior to the production of the green sand. The interior part of the specimen consists of argillaceous matter, probably containing a large proportion of oxide of iron: but the covering of the animal still retains its black shining color, although apparently carbonaceous. The broken state of nearly all the specimens, renders it difficult to determine whether they belonged to more than one species, although they probably did: and for the same reason I have thought that many drawings would not be of use. (Plate XII. Fig. 31.)

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* Geology of the S. East part of England, p. 280.

† Ossemens Fossiles, Tome 2d, p. 342.

‡ Dictionnaire de Histoir Naturelle, Art. Terrains.

Fossil crabs have not, I believe, been found in the European plastic clay; but they occur in the London clay, which is probably only the upper beds of that formation.

Zoophyta. In the bituminous conglomerate that occurs in rolled masses in the same green sand, I found a branching zoophyte, which may perhaps belong to the genus madrepora; though its characters are indistinct.

In the same green sand, and also in the ferruginous sand associated with it, we find numerous concretions whose interior part appears to be compact argillaceous oxide of iron, with the pisiform ore disseminated. Their shape is so exceedingly like that of several of the alcyonia, that I suspect they are petrifactions of those singular animals. They are generally more or less rolled, though not as much so as the crabs. Plate XII. Figs. 26 and 27 represent two of these relics. Both of them resemble species of the genus *Manon* figured in Goldfuss' Petrifacta. Fig. 27 looks like his *Manon Peziza.*

On the surface of some of these specimens small pebbles are sometimes seen; and I have occasionally found them disseminated through the specimen. In such case it may reasonably be doubted whether an animal once occupied the place of the nodule. Yet if the principal part of it be hydrate of iron, I can conceive how a few pebbles might be introduced along with the iron as it gradually took the place of the animal. Still, I am not in a little doubt as to the origin of these nodules.

Testacea. I found in the green and ferruginous sand at Gay Head, the cast of three genera, of shells. As the shell itself is wanting, the characters are indistinct; and there is evidence that the specimens have been more or less rolled; but the two bivalves are probably referable to the genera Venus and Tellina, and the univalve to the genus Turbo. The mineralizer is the same ferruginous clay, or perhaps argillaceous oxide of iron, which has petrified the crabs and zoophytes. Hence they all probably had the same origin. Plate XI. Fig. 3, is a sketch of the Venus: Fig. 5, of the Tellina: Fig. 4. of the Turbo. The latter is obviously somewhat broken. I could find only two specimens of it. Of the Venus, I found only three or four; but I obtained 20 or 30 of the Tellina.

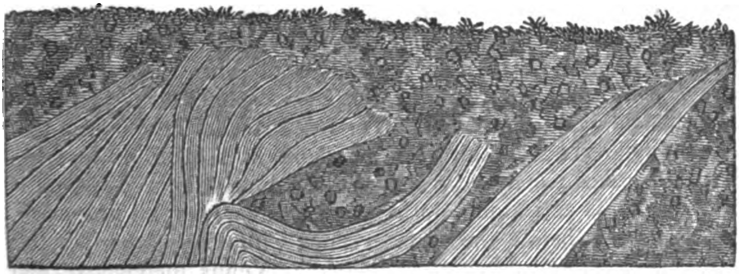
Dip, Direction, Thickness, and Superposition, of the Strata.

In giving the character of the varieties of this formation, I have anticipated much that properly belongs to this place.

One peculiarity in the clay of this formation, both on the Vineyard and on Cape Cod, is the very general want of a slaty structure. The strata seams are also often indistinct; so that it needs careful examination to ascertain the dip or direction of the beds. Sometimes, however, the schistose layers are obvious, as in some part of the cliff in the southeast part of Chilmark.

I have already remarked, that the strata at Gay Head, dip from 20° to 45° a little to the east of north; and of course they run nearly east and west. Without careful examination, however, that cliff would be regarded as an unstratified mass of clay, sand, and lignite. And in respect to some part of it, particularly its southern part, I am still in doubt whether the dip and direction of the beds correspond to the above statement.

At the cliff in the east part of Chilmark, some of the clay is schistose, and there we find the following section. A considerable part of the cliff there, from 20 to 30 feet high, is covered by diluvium, which has slidden down from the upper part. But where the strata are exposed to view, they present the curved, contorted, and inclined appearance exhibited below. The general dip, it will be seen, is towards the south, as the left hand side of the sketch is the southern extremity of the cliff. The sketch embraces a horizontal distance of about five rods. The geologist sees at once, that such a cliff needs only to be consolidated, in order to constitute a graywacke formation; as I shall show by presenting a similar sketch of a ledge of graywacke in Newport, R. Island, when I come to treat of that rock.



Section in the Plastic Clay: Chilmark.

Inference.

After the preceding description, it seems to me that no geologist will hesitate to refer this formation to the Plastic Clay of European authors. The variegated clays, the interstratified lignites with amber, and the intermixture of marine animals with terrestial vegetable remains, must settle the question. Some peculiarities, have, indeed been pointed out in the formation at the Vineyard. But they are fewer than we might expect in depositions so widely separated from one another as this is from those in Europe.

I ought perhaps to remark that some of the ablest European geologists are beginning to discard the Plastic Clay from the list of formations, and to adopt other divisions of the tertiary strata, founded upon what they regard as more definite characters. The President of the London Geological Society, in his anniversary address for 1833, rejects the term Plastic Clay: as does also Mr. Lyell, in the third volume of his Principles of Geology. He divides all the tertiary strata into four groups, distinguished by their organic remains; viz. the Newer Pliocene, the Older Pliocene, the Miocene, and the Eocene—reckoning in a descending order. The Plastic Clay falls into the Eocene, or oldest group.

Other places covered with the Plastic Clay.

Nantucket.

I colored this island as underlaid with plastic clay, not without strong suspicions that its surface may be composed of a formation higher up in the series. Its surface is entirely spread over with sand, whose upper part has been disturbed by diluvial action, and in perhaps no place do its cliffs rise more than 100 feet above the ocean. But clay exists beneath this stratum of sand, and is somewhat variegated, though generally bluish. In this clay I found a single fossil much disintegrated: but it was a native of the formation, and was contained in ferruginous sand interstatified with the clay. It resembles the genus found in the newest tertiary, as mentioned in the proper place. Twenty or thirty feet higher, in this same cliff, I found worn specimens of *Natica heros,* (Say) and *Pyrula carica,* (Lamark): but I am inclined to regard them as either diluvial or alluvial. Yet Lt. Prescott informs me that similar shells are found all over the island, from 10 to 60 feet below the surface: and he presented me with an uninjured specimen of the Pyrula carica dug up by a well digger, several years ago, 30 or 40 feet below the surface, along with many other shells; among which, were Mactra soliddissima, Venus mercenaria, and castanea, Crepidula fornicata, Solen ensis, Pecten, Arca, &c.: all of which now inhabit the neighboring ocean. Can it be that the diluvium is so thick as 30 or 40 feet? Or must we suppose that the spot where the town of Nantucket now stands, where these shells were dug up, is alluvial? Or finally can we admit that the upper stratum of sand on this island is one of the most recent of the tertiary formations? The second supposition may probably prove the true one.

I was not able satisfactorily to ascertain the dip of the clay beds on Nantucket. But Lt. Prescott, on whose accuracy of observation I place great reliance, is confident that they dip a few degrees to the south: and my own examination of some quite limited clay pits, rather confirms this opinion.

What is the dip of the Plastic Clay?

In no other place, except those above described, have I observed the dip of this formation. But it will be seen that there is great discrepancy in the dip as observed at two places on the Vineyard, and on Nantucket: and I confess my inability to determine whether there is any predominant dip in these strata. It is interesting to ascertain that this formation has a dip at all; since it seems thus more nearly identified with the well known plastic clay of the Isle of Wight, so well described by Mr. Webster; and since also this fact has such an important bearing upon the theory of the formation. But it is doubtful whether its predominant dip can be determined from patches so limited as those which are found in Massachusetts.

Elie de Beaumont represents 'the extensive deposites, in part tertiary, and in part diluvial, which lie between the Alleganies and the ocean on the east, from Nantucket to Florida, as resting directly on the inclined edges of the older rocks, and exhibiting in themselves no traces of dislocation.'* But unless my senses have greatly deceived me, we have on Martha's Vineyard most decisive evidence of dislocation in one of the higher members of these deposites: for Dr. Morton has proved, that farther to the south, a part of the beds of this vast formation are equivalents of the higher secondary strata in Europe. If, therefore, the inclined position of the strata on the Vineyard be not a solitary case, resulting from local disturbances, Beaumont's position is untenable, and his inferences, dependant on that position, incorrect.

In Truro.

Truro is the extreme town but one on Cape Cod; and on the eastern shore is a patch of plastic clay, large enough for one or two good farms, on which stands a light house, as at Gay Head. The clays here are somewhat variegated; though the predominant color is blue. They exhibit also, the same unstratified aspect, as at Gay Head; and are, I doubt not, another remnant of the same formation. I did not, however, give the spot that protracted examination which would be necessary to ascertain the dip of the strata, and whether they contain any organic remains: not being then aware that the formation had such important connections as I now suppose it to have. The spot deserves further examination.

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* Recherches, &c. p. 320, chap. 1.

In Duxbury.

Clay is not unfrequently found beneath the sands of Cape Cod; though I am not aware that any cliffs of considerable height occur except in Truro; nor that any organic remains of interest have been found in it. But in Duxbury, in Plymouth county, I have ascertained, since the publication of the first edition of the first part of my Report, that strata and organic remains exist there, identical with those at Gay Head. I am much indebted to the Rev. Benjamin Kent, of that place, for communicating to me a very detailed account of these strata and relics, made out after personal examination. It appears that 30 years ago, a well was dug near the edge of a plain of considerable extent, about 4 1-2 miles from the sea, and nearly surrounded by a swamp. Coarse gravel (diluvium) occupied the surface; next came a layer of 'vegetable earth,' in which, 20 feet from the surface, was found 'a large fallen oak (?) tree.' Next a stratum of tough blue clay, six inches thick; next strata of 'iron ore, or gravel impregnated with it:' 'below this, lay the shells, &c. in apparently fresh marsh mud' (green sand?) Here were found a very perfect shark's tooth, (Plate XIII. Fig. 37,) the cast of a small species of Venus, (Fig. 40,) and the same species of Turbo that occurs at Gay Head. (Plate XII. Fig. 4.) Mr. Kent took the trouble of having a shaft sunk on the margin of the swamp in the vicinity of this well; and the strata penetrated, correspond with those mentioned above. The water rushing into the opening, however, prevented him from examining thoroughly for petrifactions.

Another well was opened 10 years ago, 80 rods nearer the sea than the first mentioned, and at a lower level. After digging 13 feet, through strata similar to those in the first well, they came to a solid layer of ferruginous sandstone, which arrested their progress. 'Angry with disappointment,' said the owner of the well, 'my man brought a thundering blow upon the rock, and through it went; and up spouted the water. We then cleared away and found a plate of iron (ore) about two inches thick: under this plate lay a bed of strong marsh mud, full of cohogs and clams, and cockles, about two bushels of which we took out. In the centre lay plainly *a land animal's bone*, as large as my wrist, and six inches long, fractured, which was given to some Society in Boston.' This fine collection has nearly disappeared. Mr. Kent, however, sent me a single specimen, a cast of a Venus, much abraded, not to be distinguished in size and shape from that sketched on Plate XII. Fig. 3. The mineralizer in this case is clay; not so much indurated but that it may be cut without difficulty. And this is the case with all the Duxbury specimens, except the shark's tooth, which is not mineralized, or only partially so. In the specimen from the second well, mentioned above, in the cavity occupied by the hinge, is a small quantity of green sand, exactly like that at Gay Head; which proves satisfactorily the identity of the marsh mud and the green sand: and that the green sand of Gay Head is identical with that in England, a comparison of specimens shows.

Thus it appears that the proof is as strong as could be desired, of the entire similarity between the plastic clay of Gay Head, and the fossiliferous formation above described at Duxbury. True, no variegated clays are mentioned at Duxbury: nor, if I rightly recollect, do any variegated clays occur above the green sand at Gay Head: but a blue clay only. And probably by penetrating the strata deeper at Duxbury, the variegated clays might be brought to light. A question hence arises whether the green sand ought to be re garded as belonging to the plastic clay? Some writers do, indeed, limit the plastic clay formation to the variegated clays: but that the lignites and green sand belong to the same formation, (understanding by that term, a consecutive and parallel series of strata produced during the same geological period,) there can be no doubt. Not improbably, however, the green sand in this country occupies the same situation with regard to the variegated clays, as the London clay does in England with respect to those clays. But probably the London clay ought not to be separated from the plastic clay.

The facts discovered at Duxbury render it extremely probable that the extensive sandy deposites in Plymouth and Barnstable counties are underlaid by plastic clays; although the powerful diluvial action to which that region has been subjected, may have spread these sands over other formations. The sands that occur along the west side of Narraganset Bay, in Rhode Island, in the vicinity of Providence, may probably belong to the same formation. It is to be hoped that when more of the cliffs and pits in this formation have been examined, a richer variety of organic remains will be brought to light.

Relative Position of Plastic Clay.

In Europe plastic clay lies immediately above the chalk. But in this country the chalk appears to be wanting; and Dr. Morton has shown satisfactorily that its equivalent is the Ferruginous Sand Formation.* In the middle and southern states, the plastic clay lies immediately above this ferruginous sand. But I have no evidence that this is or is not the case, in Massachusetts, except analogy; which, in the present case, must be considered very strong in favor of the affirmative. The spot most likely to afford light on this point is Gay Head. But the action of the sea has been so powerful there, that little of the ferruginous sand, if it once existed, has been spared.

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* Journal Acad. Natural Sciences, Vol. VI; also American Journal of Science, Vols. XVII and XVIII.

Extent of the Plastic Clay Formation.

The patches of this formation that have been described in Massachusetts, are doubtless only the remnants of a vast extent of these strata, extending at least from Cape Cod to the borders of the Gulf of Mexico; and how far eastward, where the Atlantic now rolls, we can form no probable opinion: though there is some reason for supposing that they once even reached Europe; along whose shores similar strata are found at present. As we proceed southward along the coast from Martha's Vineyard, the plastic clay appears on Long Island, in N. Jersey, and Maryland, at Natches, at the Chicasaw Bluffs, &c; according to the statements of Mr. Finch.* If this should prove to be one continuous formation as there is some reason for supposing, it will be by far the most extensive deposite of this kind hitherto discovered. We do know that this and other tertiary formations, with the ferruginous sand, which is the highest of the secondary rocks, occupy nearly all that wide range of level country lying along the Atlantic coast of the Southern States.

Theoretical Considerations.

It is universally agreed that all the tertiary formations have been deposited from materials diffused or dissolved in water; and it is now generally admitted that these deposites took place in independent basins and at various epochs. One of the most remarkable facts in relation to these deposites, is the frequent alternation, or admixture, of marine with fresh water or terrestrial relics. Thus, at Gay Head, we have lignites and dicotyledonous vegetables mixed and probably alternating with the remains of sharks, alcyonites, crabs, and marine shells. In some instances, such facts may be explained by supposing alternate elevations and depressions of the surface, so as to bring salt and fresh water successively over these deposites. But more usually it is probable these strata were deposited in estuaries, which were occasionally inundated by fresh water: and as in early times the earth's surface was perhaps, more level than at present, these inundations might be more extensive than any that now occur.

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*Am. Journal of Science Vol. VII. p. 34: also Conrad's Fossil Shells Vol. I. p. 14.

Another interesting fact, which has been recently established by Beaumont, Desnoyers, Boue, and others, is, that during the period in which these tertiary deposites were proceeding, violent convulsions, succeeded by long intervals of repose, took place; by which some of the highest mountains on the globe were elevated, and portions of these formations elevated, along with them; so as now to crown their summits. Such facts have opened a new field for chronological geology: and in our country it is yet entirely untrodden.

Another interesting fact, which appears to be well established in the third volume of Mr. Lyell's 'Principles of Geology,'* is the admixture of recent and extinct species of testacea in the the tertiary formations. In his Newer Pliocene Strata, which is the uppermost or most recent group, he finds that 'the proportion of living species, where least considerable, usually approaches to one half of the total number, and appears always to exceed a third.' In the next inferior group, or Older Pliocene, the relative proportion is not much different; but this group is distinguished by certain peculiar species. In the Miocene Strata 1021 species have been found, of which 176 only, or about 18 in 100, are recent. And in the Eocene or oldest group, of 1238 species, 42 only are identical with living species. This gradual decrease of recent species as we descend deeper into the earth, corresponds with what we know of the organic remains in the older fossiliferous rocks, and seems to indicate successive destructions and renewals of animal and vegetable life at various periods in the history of our globe.

Although the newest tertiary in this State appears to have remained undisturbed since its deposition, yet it is interesting to find that our plastic clay has experienced a convulsion, almost equal to that by which its strata, in the Isle of Wight, have been thrown into a vertical position.† As to the period when the strata at Martha's Vineyard were elevated, I can say but little. I have already expressed an opinion that a granite ridge passes along the western side of that Island, not far beneath the surface: but I have searched in vain there for any of the more recent unstratified rocks. At present, then, I must conclude that we have no evidence of the action of any disturbing force since the protrusion of this granite. But in Europe, I believe no rock above the chalk has been proved to have been disturbed by granite; and hence I hesitate to impute the elevation of our plastic clay to that rock, especially on such equivocal evidence as I now possess.

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* Pages 53, 54, 55.

† Geological Transactions, Vol. II. p. 161.

Supposed evidence of Volcanic Agency at Gay Head.

The opinion, I ought, however, to remark, has been advanced by writers too respectable to be passed unnoticed, that there are traces of volcanic action at Gay Head. The great quantity of lignite there mixed with the clay, giving the whole mass an appearance somewhat like cinders, and the ferruginous conglomerate, in which the pebbles are coated over with the brown hydrate of iron, often exceedingly resembling the conglomerated semi-fused mass that is raked out of a furnace, would very naturally lead a person, unpractised in geology, to refer them to volcanic agency. These are undoubtedly the substances intended by Dr. Baylies, when he speaks of 'masses of charcoal,' and 'large stones, whose surfaces were vitrified,'* It is now well understood, that neither lignite nor the hydrate of iron, require heat for their production.

Geological speculations of the Aborigines.

Gay Head being naturally a place of resort for the Indians, they could not but notice its peculiarities. And they had an advantage over geologists of modern times in explaining phenomena. For when a difficulty presented itself, they had only to call in the aid of some mighty spirit, or giant, who once inhabited the spot. This they have done in attempting to account for appearances at Gay Head. I am indebted to C. C. Baldwin, Esq. Librarian of the American Antiquarian Society, for an interesting extract, exhibiting the Indian tradition on this subject. He has added another extract, showing the Indian Philosophy of Fogs on the coast: and another from the writings of Cotton Mather relating to some fossil bones found in Virginia, which is a good exhibition of the manner in which such facts were regarded a century ago. I take the liberty to subjoin the entire letter.

Worcester, July 7, 1832.

My Dear Sir,

I will now comply with my promise in relation to the interesting Fossil Remains, which you found in your recent visit to the Elizabeth Islands.

'The first Indian who came to the Vineyard, was brought thither with his dog on a cake of ice. When he came to Gay Head, he found a very large man, whose name was Moshop. He had a wife and five children, four sons and one daughter; and lived in the den. He used to catch whales and then pluck up trees, and make a fire and roast them. The *coals* of the *trees*, and the *bones* of the *whales*, are now to be seen. After he was tired of staying here, he told his children to go and play ball on the beach that joined Noman's Land to Gay Head. He then made a mark with his toe across the beach at each end, and so deep, that the water followed and cut away the beach: so that his children were in fear of drowning. They took their sister up and held her out of the water. He told them to act as if they were going to kill whales; and they were all turned into Killers, (a fish so called). The sister was dressed in large stripes. He gave them a strict charge to be kind to her. His wife mourned the loss of her children so exceedingly that he threw her away. She fell upon Seconet, near the rocks, where she lived sometime, exacting contribution of all who passed by water. After a while she was changed into a stone. The entire shape remained for many years. But after the English came, some of them broke off the arms, head, &c. but the most of the body remains to this day. Moshop went away, nobody knows whither. He had no conversation with the Indians, but was kind to them by sending them whales, &c. ashore for them to eat. But after they grew thick around him, he left them.' *See Mass. His. Collections, Vol.* 1. *p.* 139.

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* Transactions of the Amer. Acad. of Arts and Sciences, Vol. II. part I. p. 150.

'In former times, a great many moons ago, a bird, extraordinary for its size, used often to visit the south shore of Cape Cod, and carry from thence a vast number of small children.

Maushop, who was an Indian Giant, as fame reports, resided in these parts. Enraged at the havoc among the children, he, on a certain time, waded into the sea in pursuit of the bird, till he had crossed the Sound, and reached Nantucket. Before Maushop forded the Sound, the Island was unknown to the Aborigines of America.

Tradition says that Maushop found the bones of the Children in a heap under a large tree. He then wishing to smoke a pipe, ransacked the Island for tobacco; but finding none, he filled his pipe with poke, a weed which the Indians sometimes used as its substitute. Ever since the memorable event, fogs have been frequent at Nantucket and on the Cape. In allusion to this tradition, when the Aborigines observed a fog rising, they would say, 'There comes Old Maushop's smoke.''—*See Mass. His. Collections, Vol.* 5, *p.* 57.

I have made the above extracts, thinking they might interest you in your inquiries in relation to the bones at Gay Head. And I cannot but be of opinion that the above interesting tradition about the existence of the Giant, had its origin with the Indians from their having found the skeletons of large marine animals. Perhaps two hundred years ago, as late a period as the traditton refers to, the bones might have presented very different appearances from what they now do.

In the collections of MSS. belonging to the Society of which I am Librarian, are copies of letters addressed by the Learned Cotton Mather to different persons residing in Europe. They are entitled 'Curiosa Americana.' Among them are eight letters to Dr. James Jurin. One of these is entitled 'A Monstrous Dragon.' But before speaking of the paticular subject of his letter, he gives an account of all the stupendous snakes which have been described by the ancients. The letter shall speak for itself. It concludes as follows:

'A few months ago, near the Falls of James River in Virginia, Some [persons] digging a water course for a mill, by a small Run of Water under the Side of an Hill, Ten foot under ground, they found the Back bone of a snake, lying in such a form as this〰. They dug along from the Head to the Tail of it, both which were much decayed, but the earth about the decayed parts was of a different color from all the earth about it. These, with all the bones, were found exactly of the same depth under ground. It was about a mile and half distant from the great River, and about one hundred and fifty miles from the sea. But now for the Prodigy. The Monster extends above one hundred and fifty foot in length. A credible person who measured the Trench out of which it was taken, brings the account unto us, and brings with him one Joint of the Back bone, which the workmen gave him, and which I find is Five inches and a quarter in depth, Five inches and a half in width, Four inches and an half Diameter backwards and forwards, and though it be grown very dry, and some of it be worn off yet it weighs thirty three ounces and an half. *Monstum horrendum.*

I shall not go to trouble you with any of my poor speculations on the subject: chusing and wishing rather to be instructed from yours. And so, only praying for your Deliverance from a *greater Dragon* than that whose Bones were lately found in Virginia, I subscribe,

Sir, your most hearty Servant.'

COTTON MATHER.

June 3, 1723.

I do not know that this letter has ever been published. That fact may be ascertained by a reference to the Transactions of the Royal Society, or the 'Philosophical Transactions.' The author of the letter above, had, at the time of its date, in England as well as in America, a high reputation for learning and it is altogether probable that it was published there. I have never heard that it had been published in this country, and presume that it never was.

Accept I pray you, my best wishes for your health and happiness, and believe me to be with

Very great respect and regard,
Your Friend and Servant,
CHRISTOPHER COLUMBUS BALDWIN, LIB. A.A.S.

4. NEW RED SANDSTONE.

Terrain Poecilien et Peneens. Brongniart.* *Poecilite* Conybeare.†

Under this name I have included all the sandstone in the valley of the Connecticut; extending from New Haven, Ct. to the north line of Massachusetts in Northfield. On a geological map, given in the 6th volume of the American Journal of Science, I have marked the inferior beds of this formation as Old Red Sandstone. Nor do I now deny the existence of this rock in that valley. But I have not discovered marks enough to identify it so clearly, as to be justified in giving it a place on the Map. I think I can identify the upper beds of this formation with the New Red Sandstone of Europe; or rather, show it to be probable that these beds are the equivalent of the new red sandstone. And not improbably the lower beds correspond essentially with the old red sandstone of Europe: for sometimes in that quarter of the globe, the two series are in contact: as in Arran in Scotland;‡ although generally they are separated by the coal measures. But as long as we have no certain evidence of the existence of the old red sandstone in the valley of the Connecticut, it is better to consider all the beds of the sandstone there, as belonging to the new red sandstone: nor shall we have any difficulty in finding a place for the whole series within the wide range embraced by the usual definition of this rock.

In the paper above refered to, I formerly described the upper beds of the sandstone under consideration, as the Coal Formation; not however, without suggesting doubts, as to its identity with the coal measures of Europe. Thin seams of genuine bituminous coal, do, indeed, occur in the series, in gray micaceous sandstone; and its resemblance to the coal measures of Europe, has induced men of great experience to explore it for coal. But only a small quantity has ever been found; and it said that coal occurs also, in the new red sandstone on the continent of Europe: so that the occurrence of coal, is by no means certain evidence, that the rock in which it is found, is the real coal formation of geological writers.

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* Tableau Des Terrains, p. 244.

† Report on Geology for 1832, p. 382.

‡ Macculloch's Geology, Vol. I. p. 274.

For the most part, the ranges of greenstone in the Connecticut valley separate the upper from the lower beds of the sandstone under consideration: so that, if any should choose to distinguish between them on the Map, they can do it, by recollecting that the sandstone on the east side of the greenstone, belongs to the upper beds; and that on the west side, to the lower ones.

I found my opinion, that the upper beds of this formation are the new red sandstone, upon the following facts: 1. The discovery of a vertebral animal several feet long in East Windsor, Ct. in one of the varieties of this rock, 18 feet below its surface. Now, if I mistake not, no vertebral animal (except the relics of a few fish, perhaps,) have ever been found below the new red sandstone; especially bones that are merely preserved, and not at all petrified, as is the case with those at East Windsor. In Europe a few saurian animals have been found in this rock: and probably it was an animal of this description that was found in Connecticut. 2. The occurrence of fossil fish, as at Sunderland; one of the species of which, (*Palaeothrissum freslebenense,*) and the rock containing it so exactly resemble specimens of the same from Mansfield and Hesse in Germany, that Prof. Al. Brongniart could distinguish them only by their labels. But the rocks in Germany containing these fish, belong to the new red sandstone group. They occur also at Autun in France, and at one or two places in Great Britian, with precisely the same characters; the rock being a member of the new red sandstone. Hence the probability is strong that the rock containing them along Connecticut river, is the new red sandstone, or its equivalent. 3. One variety of the new red sandstone group in Germany, (the copper slate,) is wrought, as an ore of copper: and veins of similar ores occur in the Connecticut valley; frequently passing from the sandstone into the adjoining greenstone; and in one or two cases, I have observed thin layers of sandstone, considerably charged with the green carbonate of copper. This may perhaps, be considered as corroborative evidence that the formations in the two countries are contemporaneous; or that they were produced under similar circumstances. 4. The sulphates of baryta and strontia, are found in the new red sandstone of England; the latter 'stellated on carbonate of lime' near Bristol; and they occur under similar circumstances, as will be more particularly described hereafter, in the sandstone group of the Connecticut valley. Magnetic iron sand also proceeds from this rock here, as on the banks of the Mersey, opposite Liverpool. 5. In Germany, bituminous marlite occurs only in the new red sandstone group. Fetid limestone is there, also a member of the same formation. In Massachusetts, likewise, the same rocks are similarly associated; and I have lately ascertained that a part of the slate containing ichthyolites at Sunderland, is the bituminous marlite. 6. Werner regarded the variegated appearance of the new red sandstone as characteristic of the formation; and hence his name of 'bunter sandstein.' In the Connecticut valley this aspect is not very common. But in Bernardston, the lower beds exhibit it on a large scale: and on the banks of Westfield river are several interstratified layers, affording beautiful examples of this structure in hand specimens; and it is particularly interesting that these cannot be distinguished by the eye from specimens from Nova Scotia, associated with gypsum; and therefore unquestionably belonging to the new red sandstone group. Similar specimens may be obtained at South Hadley Canal on the West Springfield shore.

Mineralogical Characters of the New Red Sandstone.

'Taken as a mass,' says De la Beche,* 'the group (of new red sandstone) may be considered as a deposit of conglomerate, sandstone, and marl, in which limestones occasionally appear in certain terms of the series; sometimes one calcareous deposit being absent, as the muschelkalk is in England; sometimes the zechstein, as in the east and south of France; and sometimes both being wanting as in Devonshire.' 'The beds' says Dr. Macculloch,† 'are sometimes of a conglomerate structure, at others a fine sandstone and occasionally schistose; and in composition, the rock is calcareous, argillaceous, or ferruginous, or all together presenting endless variations of aspect and color.'

These descriptions correspond in general to the group which I denominate new red sandstone in the Connecticut valley. Our rock, however, is more deficient in calcareous matter than is usual in Europe: though more or less of lime is scattered through all the members of the group; so that in some cases even the reddish shales slightly effervesce with acids: and might, therefore, be properly called *red marl.* Nearly all the limestone in the group is highly fetid; though in some instances this passes into that which is bituminous; and even into bituminous marlite.

It should be recollected, also, that this formation is wanting in gypsum and rock salt; two minerals found in it almost universally: though as mentioned in the first part of my Report, a minute quantity of the former has been found at West Springfield, and South Hadley. I have, however, compared a suite of specimens from the new red sandstone containing gypsum in Nova Scotia, with a suite from the Connecticut valley, and with the exception of the limestones, they can hardly be distinguished from one another.

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* Geological Manual, p. 386. † System of Geology, Vol. II. p. 227.

Indeed, why may we not suppose gypsum and rock salt to be occasionally wanting in this formation, as well as limestone?

The following distinct varieties of rock compose the new red sandstone in the valley of the Connecticut.

1. *Conglomerates.* A conglomerate, composed almost entirely of the ruins of granite and mica slate, forms, in connection with a sandstone of similar character, all the lower beds of this formation; and these two varieties embrace all the rock in Massachusetts and Connecticut, that has usually been denominated *old red sandstone.* The two varieties pass into each other by insensible gradations, and even the finest portion of the sandstone is coarse. The strata are from one to two, and even three or four feet thick; and for the most part, the slaty structure is almost entirely wanting. The prevailing and almost uniform color of the rock is red; and even the imbedded nodules, when not very large or compact, are penetrated with this color. Yet where this rock approaches granite and mica slate, as in Bernardston, Greenfield, Deerfield, Whately, and Southampton, it is somewhat variegated; some portions of it being of a light gray color; as if a heat so powerful had been applied to it, as partially to expel the iron, or change it from an oxide into some other compound. The nodules of the conglomerate are sometimes one or two feet in diameter; but for the most part, they are only a few inches thick. A variety occurs in Bernardston, Southampton, &c. (Nos. 135, 136,) which can hardly be distinguished in hand specimens from granite; being composed of fragments, but little rounded, of quartz and feldspar; the latter of a flesh color. Sometimes the nodules, as at Sugar Loaf, in Deerfield, are graphic granite, which is often quite beautiful; the feldspar being of a lively flesh color.

In Greenfield and Bernardston, near the junction of the new red sandstone formation with the argillo-micaceous slate, the conglomerate occurs, composed of argillo-micaceous slate and white quartz. This was obviously derived from the detritus of the slate against which it rests. The general color of this rock is red; and even the mica slate on which it reposes, exhibits the same color several feet from the junction. (Nos. 137 to 139.)

Another variety of conglomerate, which is found only in connection with the upper beds of the new red sandstone, is of a dark, reddish gray color, and is composed of fragments of mica slate, talcose slate, chlorite slate, hornblende slate, and slaty quartz rock, with occasional nodules of quartz, feldspar, and granite. The cement appears to be the same materials comminuted. This is the coarsest conglomerate in the Connecticut valley. It constitutes a considerable part of mount Toby, in Sunderland, where the imbedded nodules are sometimes three or four feet in diameter. It extends through Montague, and at the mouth of Miller's river, as well as on the opposite side of the Connecticut at that place, it may be examined to good advantage. South of Sunderland I have not found it, except at Durham, in Connecticut. Unless viewed on a large scale, this rock scarcely exhibits any stratification. The strata are sometimes eight or ten feet thick. (Nos. 140 to 143.)

At Turner's falls a much finer and more compact gray conglomerate exhibits itself, composed of the same materials as the last, except that it abounds more in quartz and feldspar. (No. 150.)

A reddish conglomerate, made up of nearly the same materials as that first described, (except that it contains more slate,) abounds among the lowest of the upper beds of this formation. (Nos. 144 to 147.) It is not as coarse as the last, and the strata are usually less than a foot thick. It is common in mount Toby and on the east side of mount Holyoke, in Granby.

Trap conglomerate is another variety of no small interest. It reposes on the greenstone on the east side of mount Tom and Holyoke; and consists of a mixture of angular and rounded masses of trap and sandstone, with a cement of the same materials. The nodules are sometimes one or two feet in diameter, and the stratification is not very distinct. I do not doubt but the same rock may be found on the east side of nearly all the greenstone ranges in the Connecticut valley. Its thickness is but small, and its mode of production obscure. (Nos. 151, 152, and 285.)

2. *Sandstones.* The lowest and most abundant sandstone in this formation has been described with sufficient minuteness, in connection with the conglomerate with which it occurs. It is used somewhat extensively for architectural purposes. (Nos. 154 to 161.)

A sandstone, which, at a little distance resembles that just described, is found among the upper beds of this formation in Longmeadow and Wilbraham; where it is extensively quarried. It differs, however, essentially from the last variety; being composed chiefly of fine siliceous sand, with occasional specks of mica, cemented probably by the red oxide of iron: for its color is almost blood red. Its particles, however, do not cohere strongly; and this forms the only objection to its use in architecture. The extensive quarries in Chatham, Ct. are opened in this rock; or in a variety closely allied to it. Its strata are thick and rarely exhibit a slaty structure. (Nos. 165, 166.)

Gray sandstone is not uncommon in this formation; but it is found chiefly in the upper part of the series; or rather in the vicinity of trap rocks; as at Turner's falls, and on both sides of Holyoke and Tom. It is made up of coarse gray sand—sometimes of comminuted granite entirely, as on Holyoke—and varies in color from light to dark gray. In some localities, as in Granby, the strata are thick, and the rock is scarcely schistose; it is there used in architecture. In other places, the strata become thinner. On the banks of Westfield river, in West Springfield, I noticed a variety that resembles the grindstones brought from Nova Scotia, though it is harder.

Gray micaceous sandstone. When the last variety takes mica into its composition, it becomes more easily divisible into laminae; and where that mineral abounds, it is very fissile. Some specimens of this kind, found in the vicinity of trap rocks, can hardly be distinguished, in hand specimens, from mica slate. (Nos. 177, 178, 179.) Gray micaceous sandstone abounds at Turner's falls, on Mt. Toby, in South Hadley, in West Springfield, &c.

Variegated sandstone. This is composed of alternating laminae of light and dark red sandstone, usually somewhat micaceous. The layers are not very evenly arranged; so that their edges present rather a fantastic appearance. I have scarcely met with this rock except on the banks of Westfield river, half a mile west of the village of West Springfield; where the characteristics of the new red sandstone are more fully developed than any where else in the valley of the Connecticut. The variegated sandstone there forms thick and workable strata.

Brecciated sandstone. This is composed of fragments of micaceous sandstone, which seem to have been partially fused and then reunited. It is almost as hard as siliceous slate. It is found about a mile east of Turner's falls, on both banks of Connecticut river, forming a stratum some 20 feet wide. The stratification and schistose structure are very obscure: but on the north shore, the layers have evidently been forced upwards, so as to give them somewhat of a spheroidal form. I hence infer that a mass of unstratified rocks, probably greenstone, lies beneath the sandstone at no great depth; and that when this was forced upwards in a melted state, it partially fused the sandstone. (No. 174.)

Red micaceous sandstone is not unfrequently a member of this formation. The grain is usually fine, and indeed, it commonly approaches very near to shale, into which it passes: yet much of it is too coarse and contains too much siliceous matter to be called shale. It is very common along the east side of our greenstone ridges, as at Turner's falls and in West Springfield. It is quite remarkable for being divided into rhomboidal masses, by one or two sets of parallel seams. On the north bank of Westfield river, in West Springfield, this division is remarkably distinct, and the surface of the rock presents an interesting chequered aspect. The same is the case in the northeast part of Greenfield, just below Turner's falls. (Nos. 191, 192.)

3. *Shales.* (Nos. 199 to 204.) Under this term I include all the varieties of argillaceous slate, sometimes called *slate clay*, found in connection with the secondary rocks. And in Massachu-

setts such slate occurs only as a member of the new red sandstone series: of that formation it constitutes a very important part. Its colors are gray, red, and black; and in hardness it varies from that of tender schistose marls, to a degree of induration approaching that of siliceous slate. The red variety is most abundant: especially in the region of Enfield and Hartford, in Connecticut. Sometimes it takes mica and sand into its composition, and then passes into the red micaceous sandstone, as already remarked. When black, it is generally bituminous, as at Sunderland, and at Middletown, Connecticut; where are found upon it the impressions of fish and vegetables. Some of the black colored slate, as at Turner's falls, splits into irregular, somewhat weged shape pieces; and indeed, easily disintegrates and falls to pieces: when it resembles comminuted coal. It frequently contains sulphuret of iron; which by decomposition, causes the slate to exfoliate: in some places, also, as at Turner's falls, and on Chicopee and Westfield rivers, this shale abounds in nodules of argillaceous iron ore, of a poor quality. Some of the black non-bituminous shale of this formation, has almost lost its slaty structure in the process of induration. Thin pieces of it give a ringing sound when struck. This variety abounds in the vicinity of Turner's falls: as, indeed nearly every other variety does. There we find a gray variety, which is so soft that it may be impressed by the finger nail.

If it were possible to doubt that the new red sandstone formation was deposited from water, the surface of some of the layers of this shale would settle the question demonstrably. For it exhibits precisely those gentle undulations, which the loamy bottom of every river with a moderate current, presents. (No. 198.) But such a surface could never have been formed while the layers had that high inclination to the horizon, which many of them now present: so that we have here, also, decisive evidence that they have been elevated subsequent to their deposition.

On Westfield river, in West Springfield, both the red and black shales are traversed by numerous veins of satin spar; itself often of a reddish hue. They are rarely more than an inch wide, but often several feet long; and run uniformly across the laminae of the slate.

In the same place the black shale, as well as the bituminous marlite, and some varieties of slaty sandstone, contain masses of septaria, or the *Ludus Helmontii.* They vary in size from an inch to 5 or 6 inches in diameter, and are usually flattened or reniform. The envelope appears to be argillo-ferruginous as well as calcareous; and the cavities are lined, and sometimes filled, by white calcareous spar. The interior is divided into irregular masses, or sometimes into polygonal prisms.

The hypothesis which imputes the cavernous structure of these argillo-calcareous masses to desiccation, and their subsequent filling up to the infiltration of carbonate of lime in a state of solution, seems to me liable to few objections; and, indeed, is quite satisfactory. But I have already given it somewhat in detail, when speaking of columnar argillaceous iron ore.

4. *Limestones.* (Nos. 205 to 216.) When the black bituminous shale, that has been described, takes into its composition enough of calcareous matter to produce effervescence with acids, it becomes *bituminous marlite.* It is not very common in this sandstone formation. Yet one finds it in considerable quantity on the banks of Westfield river, in West Springfield; and I have ascertained that the stratum of slate in Sunderland, which contains the best preserved relics of fish, is bituminous marlite. Although this rock contains but a small proportion of calcareous matter, yet it certainly does not deserve to be described as a distinct rock; and it may be conveniently mentioned under the head of limestones.

Strongly fetid limestone occurs, interstratified with the micaceous sandstones of this formation, at two places in the northwest part of West Springfield. At the most northern locality, I noticed only a single bed about ten feet thick: but two miles south from that spot, several beds, not far apart, may be seen, associated with greenstone, as well as sandstone. The rock at both places is of a dark gray color and nearly compact. Its fetid odor when struck, is exceedingly strong, so as even to produce nausea. It is wrought to some extent for water proof cement, and it answers well. (Nos. 213 to 215.)

I doubt whether much genuine bituminous limestone exists in the new red sandstone in Massachusetts. Yet when the bituminous marlite takes a large quantity of lime into its composition, it becomes bituminous limestone; and perhaps some of this variety may be found in West Springfield. It is also said to occur in Southington and Middletown, Ct.: and the fetid limestone, also, (all of them connected with the new red sandstone,) in Northford, Ct.

At Turner's falls, on the north shore, I found, a few years ago, a stratum of coarse argillaceous limestone, a foot thick, which was neither bituminous nor fetid: but the subsequent removal of the dam over Connecticut river, has covered the spot beneath the waters.

On the banks of Westfield river, in West Springfield, we find layers of what appears to be an argillo-ferruginous limestone, interstratified with the slate, and only a few inches thick. Where the water has laid bare this rock, it sometimes presents the whole surface divided into small prisms of only a few inches in diameter and length, whose axes are perpendicular to the planes of the strata. They have four or more sides, though irregular, and their sides do not touch. They appear to have resulted from the same cause as the septaria already described; and I doubt not that both the septaria and these layers of argillo-ferruginous limestone, might be employed, as the former is in Europe, for the preparation of valuable Roman cement.

From this sketch of the mineralogical characters of this group of rocks, it will be easy to distinguish between the lower beds, which have heretofore been considered as the old red sandstone, and the upper ones, which have been called a coal formation. The lower beds are distinctly stratified, but rarely slaty; whereas the upper ones are usually so; although some varieties of conglomerate, scarcely exhibit any marks even of stratification. In the lower beds is no shale. Their color is almost uniformly some shade of red: but as already shown, the upper beds are of various colors and shale is abundant.

The greater abundance of granite nodules in the conglomerate of the lower beds of this formation, than in that of the higher, has led some geologists to regard them as belonging to distinct formations.

But as a general principle, it will not answer to conclude that conglomerate to be the oldest rock, which contains rounded masses of granite. For a deposite of granite might be so situated, that an abrading current would tear off large quantities of it, while much later rocks might flank its sides in such a manner as to be almost entirely protected from the water. The recomposed rock hence resulting would therefore contain granite nodules chiefly. Whereas it might be that the more recent rock above spoken of, once covered the granite and was worn away by an agency that could not touch the granite. Hence the earlier mechanical rock thus produced would consist chiefly of fragments of the schists. Besides, geologists now generally admit that granite is a later rock than most of the primary ones; and sometimes even of the same age as the highest of the secondary; since there is evidence that it has been protruded through the chalk: and finally, in the present instance, some of the lowest beds of the sandstone under consideration, are composed of fragments of the latest of the primary stratified rocks in the region; as in Bernardston and Greenfield, where the conglomerate is made up chiefly of argillo-micaceous slate.

Extensive ranges of greenstone are connected with the sandstone of the Connecticut valley. But I need spend no time in the present state of geological science, to show that trap rock cannot be a member of the sandstone formation, and that it was subsequently introduced. Its characters and relative position will be described when I come to speak of the unstratified rocks.

Topography of this Formation.

With a single exception, all the new red sandstone hitherto described in New England, lies in that part of the valley of Connecticut river, which extends from New Haven to the north line of Massachusetts: and in this State none is found out of that valley. An inspection of the accompanying Map, which marks out this valley, (Plate XV.) will convey a definite idea of the space covered by this formation. For the hills which are there represented as bounding the valley, commence on the outer edge of the sandstone. All the included space is sandstone, except those ranges of hills which are drawn within the valley, which are greenstone.

The single exception above referred to, embraces a valley 10 or 12 miles long, extending from Woodbury to Southbury, in Connecticut, along a branch of the Housatonic river. There we find the same varieties of sandstone, accompanied by analogous greenstone, as in the valley of the Connecticut. The two valleys are separated by a high ridge of primary rocks, through which they have no lateral communication. We hence learn that the causes which produced the new red sandstone group and the intruded trap, were not local in their operation. In New York, also, according to Prof. Eaton,* this formation commences near Utica, and extends 250 miles in length. East of New England, no new red sandstone has been found nearer than Nova Scotia, where it abounds in gypsum. From the able description of this rock by Messrs. Jackson and Alger, and from specimens furnished me by this latter gentleman, I infer a greater resemblance between the Nova Scotia and New England group, than between the latter and that in New York, and those farther west: although of the last named I have as yet only few specimens.

As the general direction of the strata of the new red sandstone in the valley of the Connecticut is north and south, and the dip easterly, it will follow that the lower beds of the group must occupy the western part of that valley. And I have already remarked that the greenstone ridges generally separate the upper from the lower beds. In Gill, Greenfield, and on Mount Holyoke, however, the observer will see schistose sandstones cropping out beneath the greenstone; though in receding westerly from the greenstone, he will find the slaty character of the rock soon to disappear.

In the central parts of the Connecticut valley, from South Hadley nearly to Middletown, the shales and finer sandstones prevail almost exclusively; so that in excavating 15,000 cubic yards of stone at Enfield Falls, not a pebble as large as an acorn was observed.* The prevailing color of the slate in that region is dull red or chocolate; and being easily decomposed, it imparts a like hue to the soil. If we suppose, what I have always observed to be true, that the prevailing dip of the strata through the whole valley is easterly, we cannot admit, as some have maintained, that these finer strata were originally deposited in its central parts, and the coarser materials on its borders, for then the finer strata must dip on both sides of the valley towards its centre, or remain horizontal; and they could not dip under the coarser layers on the east side, as they now do. We ought probably rather to infer, that the higher and coarser strata have been worn away from the central portion of the valley, because they would there be more exposed to abrading agents.

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* Survey of the Erie Canal, p. 102.

The coarser and the finer beds do not, however, in all cases, occupy separate portions of the valley exclusively; but in many places they are interstratified in almost endless variety. The section laid bare by the Connecticut, for three miles above, and nearly a mile below Turner's Falls, of which a sketch will be given in treating of greenstone, presents a good example for examination. The coarser varieties, however, are not so abundant there, as at Mount Toby in Sunderland. On the west side of Connecticut river, opposite Sunderland, Deerfield mountain exhibits nearly every variety of the lower beds of the formation. Let the observer pass to the east bank of the river at Whitmore's ferry, three miles north of Sunderland village, and he will land upon a ledge of the coarsest conglomerate that has just been described. Lying directly above this, and dipping a few degrees easterly, as do all the strata of Mount Toby, he will find the black bituminous shale containing impressions of fish; 10 feet thick. Immediately above this succeeds a coarse conglomerate, scarcely differing from that beneath, and forming a mass 200 or 300 feet thick. Proceeding southeasterly to the top of Toby, not less than 900 feet above the river, he will find numerous alternations of the coarsest conglomerates with the finest red and grey sandstones; or rather shales. And the passage from one variety to the other is not in general gradual, but sudden; so that the line between the finest and coarsest materials is well marked.

It is very obvious, in such cases, that the finer layers of the rock must have been deposited in still waters, and the coarser materials have been the result of powerful abrading currents. And I know not a more difficult point in the theory of the earth, than to explain the cause of so many and so sudden changes from motion to rest and from rest to motion, in the waters in which such rocks were formed. The facts might perhaps be explained by supposing these deposites to have resulted from the long continued action of a river, carrying into the bottom of a lake or the ocean, coarser materials during its floods, and the finer sediment at low water. But the different nature of the materials composing successive layers of the conglomerate strata, show that the current must have swept over and torn up various rocks at different times; and consequently must have come from various directions at successive periods: except perhaps in those rare cases, where it wore away the higher formations entirely. Now we cannot conceive how any river should be made to pass over rocks so different as we find in the alternating beds of mount Toby, at different periods: it would require alterations in its bed, almost without number.

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* Mr. A. Smith on the Connecticut valley, Am. Jour. Science, Vol. XXII. p. 220.

There is, however, one other mode of accounting for the facts in this case, which may perhaps be thought more satisfactory. It seems to be proved beyond all reasonable doubt, that the various mountain chains on the globe were elevated from the bottom of the ocean at various epochs, in the earlier times of our planet. And generally these elevations took place suddenly. Now the inevitable effect of such a protrusion of a huge mountain ridge, would be to produce a wave in the ocean, which would overwhelm the globe. This wave, flowing in every direction from the centre of disturbance, would attain its greatest elevation in the antipodes of that centre: and then there would succeed a reflux wave. Nor would the waters settle into repose, until several mighty flood and ebb tides had succeeded. Now a moment's reflection will convince any one, that while this wave was rising and falling, it would rush over any particular region in strong currents; but when at its maximum and minimum elevation, the water, for a considerable time, would be nearly calm. Consequently, during the former periods we should expect the materials of the rocks deposited would be coarse: and fine during the latter period. And as mountains were raised in different parts of the globe, the currents would proceed from various centres, and thus sweep into the same basin the fragments of different rocks. Such powerful convulsions could not have taken place on the globe since man was placed upon it; and it is probable that the new red sandstone was deposited prior to his creation, while the earth was yet 'without form and void,' that is, a desert and unfurnished waste.

Dip, Direction, and Thickness of the Strata.

Although subject to local variation from local causes, yet the general dip and direction of the strata of this formation are quite obvious. The direction is not far from north an south, and the dip easterly at an angle from 10° to 20°. Fifteen degrees is probably about the medium dip: and I suspect the prevailing direction to be a few degrees east of north. In particular places, however, the dip is found at all angles, from 0° to 80°. This is remarkably the case in the vicinity of Turner's falls; as may be seen on the section of that place to be given farther on. This extraordinary dip, however, appears to be easily explicable from the proximity of greenstone and granite; as I shall attempt to show when I come to treat of those rocks. Near the eastern extremity of Mount Holyoke, also, these rocks mount up on the ridge of greenstone at an angle of 55° or 60°. Here too the direction of the basset edges is about northeast and southwest. The presence of greenstone in this case, also, as I shall attempt to show, will explain these anomalies. In the West part of Westfield, and near the centre of Hatfield, the lower beds of this formation have a dip to the west of about 10°. The same is also the case in Bernardston. In the north part of Hadley, I have observed strata running nearly east and west, and dipping 10° north. The probable presence of granite at no great depth in all these cases will readily account for these exceptions.

Although the new red sandstone must come in contact with the primary rocks on both borders of the Connecticut valley, yet I have discovered the actual junction only in one spot. Half a mile south of the 'Glen,' or Gorge, in Leyden, near a saw mill, the peculiar conglomerate made up of argillo-micaceous slate and quartz, reposes upon that slate, and has a dip to the south from 20° to 30°; while the slate is nearly perpendicular, and the course of its edges nearly north and south. Admitting the elevation of the slate subsequent to the deposition of the sandstone, the southern slope of the edges of the former in Leyden, will explain the southern dip of the latter at this place.

The following are the dip and direction of the new red sandstone in several places in Massachusetts, where it does not seem to have been subject to local deviations.

Between West Springfield, and Westfield, along Westfield river, east of the greenstone; direction, north and south; dip, 15° to 20° east.

Mount Tom, beneath the greenstone; direction, north and south; dip, 15° to 20° east.

Most northerly lime quarry, West Springfield: direction north and south; dip, 15° east.

Rock Ferry, (S. Hadley, at Titan's Pier); direction, nearly north and south: dip, 20° east.

Sunderland; direction, generally north and south: dip, between 10° and 15° east. At Whitmore's Ferry, however, the stratum containing the ichthyolites, is nearly horizontal; but this is overlaid by sandstone, dipping east from 5° to 10°.

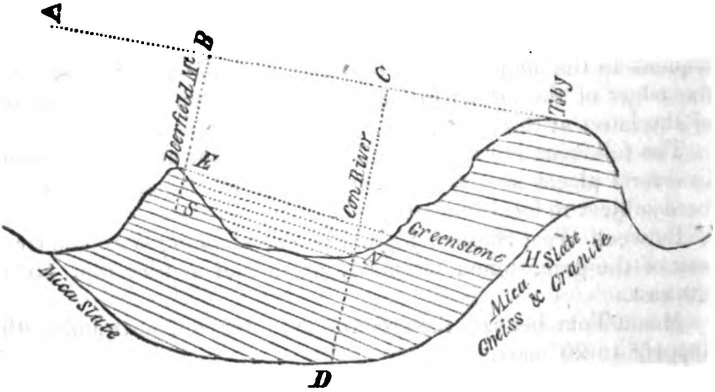
Deerfield; (Sugar Loaf and Deerfield mountain;) direction, north and south; dip, 10° to 15° east.

Do. at Hoyt's quarries, in the west part of the town; dip, 15° to 20° east.

Greenfield; near the village; dip, 20° to 30° east.

Other localities might be cited, but it seems unnecessary. It ought, however, to be mentioned, that as we go south into Connecticut, where the breadth of this formation increases, we find the dip to decrease; so as in many places to be almost nothing. In the vicinity of unstratified rocks, however, it presents much irregularity.

As to the thickness of the formation under consideration, we have not sufficient data for forming a very definite opinion. Perhaps, however, we may obtain a proximate estimate, by examining an east and west section of the formation, across the south part of Deerfield mountain, and the centre of mount Toby. The following sketch is not intended to be precisely accurate; but only to give a general idea of the relative situation of the two mountains and the intervening valley, with the valleys between them and the primary rocks on the east and west. There must always be as is well known, more or less of distortion and want of proportion in sections of this kind, where the horizontal scale must be much smaller than the perpendicular one. In the present case, in order to exhibit the proper dip of the strata, the valley through which the Connecticut flows, is represented too wide.



It will be seen by this section, that the strata, both in Deerfield mountain and mount Toby, as well as in the valleys, have the medium easterly dip of the formation; that is about 15°, though on a considerable part of mount Toby, it is hardly 10°. Two or three hundred feet above the river, on the east side, may be seen a mass of greenstone: which, so far as I can ascertain, constitutes a dyke or bed in the sandstone, and divides the upper part of the formation from the lower:

the characters of the two groups, being considerably different. Deerfield mountain, in its southern part, consists entirely of the lower beds; and the strata on the opposite side of the river beneath the greenstone, correspond in dip and general characters with those of this mountain. Mount Toby is probably not far from 1000 feet above the river, and Deerfield mountain varies from 500 to 700. These are much the most elevated points of the new red sandstone in the valley of the Connecticut: and the enquiry immediately suggests itself to the geologist, whether the formation was originally of this height throughout its whole extent, and has been subsequently worn away, except these ridges: or whether these have been raised so much above the general level by a force acting beneath. The latter supposition would seem most probable, were it not for the proof exhibited by the above section, that no peculiar disturbing force has acted on these mountains. Had that been the case, either their strata would exhibit a different dip from the formation generally, or they would not correspond on opposite sides of the river. It seems to me perfectly obvious, after inspecting both these mountains, that almost the only change their strata have undergone, was their original elevation about 10° to 15°, along with every part of the formation. And hence we are compelled to suppose, that the top of mount Toby exhibits nearly the original elevation of the whole formation. For the idea that such insulated peaks and ridges, as those under consideration, were deposited in the insulated and inclined position which they now occupy is perfectly absurd. Further we must suppose that the strata of mount Toby originally extended to the top of Deerfield mountain; as is represented by the dotted line *A C* in the section. Nay, on this suppositon, all the strata of both mountains may have extended to the western side of the valley, as at *A*.

The immense period requisite to wear away such a mass of rock as this theory supposes to have once occupied the whole valley of the Connecticut, will seem to most minds the strongest objection against its adoption: I mean supposing it to have been effected by such causes as are operating at present. But this is not a solitary example, in which geological phenomena indicate the operation of existing causes through periods of duration, inconceivably long. We may in this case, indeed, as I have already shown, suppose the occurrence of numerous deluges in the earlier periods of our globe. Still, even with the aid of such catastrophes, the work must have been immensely protracted. And why should we hesitate to admit the existence of our globe through periods as long as geological researches require; since the sacred record does not declare the time of its original creation: and since such a view of its antiquity enlarges our ideas of the operations of the Deity in respect to duration, as much as astronomy does in regard to space?

Instead of bringing us into collision with Moses, it seems to me that geology furnishes us with some of the grandest conceptions of the Divine Attributes and plans to be found in the whole circle of human knowledge.

The objection of a writer in the American Journal of Science,* that such a height of waters as would deposite mount Toby, must have produced a lake nearly to the upper part of New Hampshire, in the Connecticut valley, and thus have caused the same sandstone to be produced higher up that valley than Northfield, loses its force, when it is recollected that this formation was deposited before its strata were elevated. For the elevating force undoubtedly changed the relative level of different parts of the country. In this case, the disturbing force must have acted beneath the primary rocks. And besides, we have good evidence, which will be shown by and by, that our new red sandstone was formed beneath the ocean. We cannot then reason on this subject from present levels.

If the preceding statements and reasonings be correct, in order to ascertain the actual thickness of the new red sandstone strata in the Connecticut valley, above the river, we must add the height of mount Toby above the strata seam *E H*, to the height of Deerfield mountain: that is, *B E* to *E S*=*C N*. It certainly will not exceed the truth to call *B E* 800 feet, and *E S* 400=1200, the thickness of the strata above the bed of the Connecticut. In no place that I know of has this river cut through the sandstone: and hence we are almost entirely destitute of means of ascertaining the thickness of the strata beneath the river. If the primary strata have the same slope beneath the sandstone, as above it, this rock cannot be less than 1000 to 2000 feet thick, beneath the river, or *N D*. But this is little better than conjecture: both because the slope of the primary strata is very unequal in different places, and because probably the surface beneath the sandstone, is as uneven as it is in other primary valleys: which is evinced by the curved structure of the sandstone strata in some places.

In the second part of my Report I have described the cave and fissure in Sunderland, as having been produced by the wearing away of the inferior schistose strata, probably by water. There is another fact which the observer will notice in various places on the western declivity of Toby. The thick sandstone and conglomerate strata are often arranged in steps or terraces of great height and thickness. At first view the mountain would seem to to have been elevated by successive throes of some internal force; each paroxysm throwing up the central part of the mountain higher, and higher, so as to produce these offsets. But there is too much regularity in the stratification to admit of such a supposition. I should rather impute this terraced structure to the action of those currents of water, which have excavated the valley of the Connecticut. The rock exhibits occasionally cross seams of stratification, nearly at right angles to the surface of the layers: hence currents of water, frosts, &c. would remove successive portions as wide as these cross strata. On some of the terraces huge masses of the rock yet remain, raised from their original bed and irregularly mixed, but not far removed.

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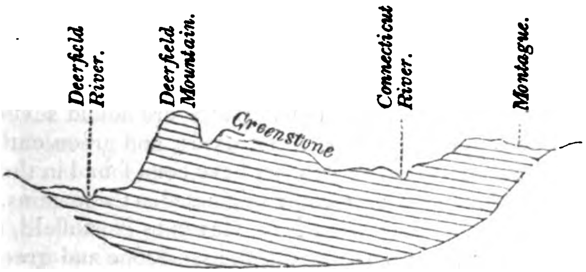
* Vol. XXII. p. 223.

It will be seen on the accompanying geological Map, that the greenstone ridge which is marked in Sunderland, crosses the Connecticut in the north part of that town and then forms its western shore as far north as Gill. The section that has just been given crosses the Connecticut a little south of the place where the greenstone crosses the river; and consequently the greenstone is represented as on the east side of the river with the sandstone beneath and above it. But north of the place where the greenstone crosses the river, through the whole extent of Montague and Deerfield, the following section represents the relative situation of the two rocks.



Now I cannot but regard this fact as some evidence that the valley between Deerfield mountain and Toby, has been to a great extent excavated by water. For I can hardly conceive how so deep a gorge should have been produced in this greenstone ridge or dyke, at the period of its protrusion: certainly not without causing great disturbance in the adjoining strata; of which I have seen no traces. The continuity of this ridge is uninterrupted; as are the dip and direction of the sandstone strata. But the whole aspect of this valley, and especially the contour of Sugar Loaf, correspond with the idea of excavation by water. The rocks in place, too, on both sides of the river, to the height of several hundred feet, bear the marks, in numerous grooves, of powerful abrading agents.

If such an hypothesis, however, be admitted, this work must have been performed while the region under consideration was in a state quite different from what it is at present; and probably by other streams than the Connecticut and its tributaries. For I have in another place attempted to show, that these streams have not, to any great extent, excavated their own beds: although the reasoning which proved this position, would not apply to the valley between Toby and Deerfield mountain, except by way of analogy. If water did excavate that valley, probably it was previous to the deposition of the tertiary strata in the Connecticut valley; since no change of consequence has taken place in the surface, (I mean by elevation or subsidence,) subsequent to that period: whereas some change of this kind must have taken place since the excavation of this valley, if other streams than the Connecticut and its tributaries performed the work.

But enough, and probably more than enough, upon a subject which is obviously involved in great obscurity. I confess that the position which I have taken, and the reasoning which I have advanced, do not satisfy my mind: but at present I can offer nothing better.

Mineral Contents.

Copper.

The veins of Copper ore, occurring at the junction of this formation with the greenstone, are the most interesting mineral treasure of the new red sandstone. Here are found several species: viz. the pyritous copper, red oxide, and green carbonate: and several masses of native copper, have been found in the valley of the Connecticut, which probably originated in these veins. The veins are quite numerous from New Haven to Northfield, and not unfrequently extend into both rocks, the sandstone and greenstone. Their gangue is sometimes sandstone, sometimes trap, and sometimes sulphate of baryta. On the most southern of the islands at Turner's falls, the gangue of the pyritous copper is a brecciated sandstone, the vein crossing the regular strata; though coinciding with them in direction. That is, both run nearly north and south; but while the slate dips about 45° easterly, the vein dips westerly. It would seem as if the intrusion of the copper ore had broken a portion of the sandstone into fragments, and the materials had been partially melted, so that on cooling, a chemical union took place between them and the walls of the vein. On the edges of the sandstone strata, for several feet and even rods, around this vein, may be seen numerous crystals of lenticular carbonate of iron. (No. 240.)

All the veins of copper ore in the formation under consideration, run in nearly the same direction, so far as I have examined them: that is, nearly north and south; indicating some common cause from which they originated.

The vein of pyritous and the green carbonate of copper, half a mile below Turner's falls, in Greenfield, affords a good example, at low water, of the passage of the vein through the trap and the sandstone. Although it has not been explored, veins of sulphate of baryta, sometimes several inches wide, and accompanied by copper, may be seen passing into both rocks. The trap is that variety denominated toadstone; the base being apparently indurated clay. The red slaty rock connected with the trap, may be regarded as a variety of shale, sometimes a little micaceous. As nearly as I could determine, this vein is perpendicular; and as it passes northerly into a lofty hill of trap, it might in that direction be advantageously explored. A few hundred dollars laid out here, would probably determine the value of the vein.

I have put down a second copper vein on the Map, a mile or two south of the one just described. I did it on what I thought good authority; but subsequent examination has led me to doubt whether it has an existence; although I am aware how easy it is to overlook such a locality without a guide.

The copper ore in Granby, Ct. (called the Simsbury Mines,) appears so far as it has been explored, to be a bed lying entirely between layers of sandstone, which dip to the east a little more than 20°, and running between north and south, and northeast and southwest. The red oxide is the principal ore, sometimes mixed with a little of the green carbonate. The gangue appears to be gray sandstone. Since this mine has been re-opened, about a thousand tons of good ore have been obtained. A new adit is now in progress, which will strike the bed of copper ore about 200 feet below the surface.

Although nothing but sandstone is found where this bed of ore crops out, yet a greenstone ridge appears a few rods distant, and the dip of the bed is towards the greenstone, and must therefore pass under it, or intersect it.

Native copper has been found in small pieces at this mine.

Coal.

It has long been known that coal was found in the sandstone of the Connecticut valley: and on this fact mainly has the opinion been based, that a real coal formation exists there. But I think I have satisfactorily shown that this formation must be referred to the new red sandstone group. Yet if this be admitted, shall we infer that there is no hope that it may contain coal in such quantity, and of such quality as to be useful for fuel? A few years ago, geologists would have peremptorily decided this question in the affirmative: but in the present state of their science, it seems to me we may at least reasonably hesitate, and perhaps draw a contrary inference. It is now generally admitted that all coal has a vegetable origin;

and that simply by the long continued action of water, under certain circumstances, vegetable matters pass into the state of peat, next into lignite, then into bituminous coal, and finally into anthracite: though this last substance more commonly, perhaps, results from the action of heat on bituminous coal: and if the heat be powerful enough, even plumbago may be produced; 'as wood has been,' (thus changed) says Dr. Macculloch,* in my experiments, and as coal is daily in the iron furnaces.' Such a change he found, in one case at least, produced upon common coal, in the vicinity of a trap dyke: hence he reasonably infers, 'that even the plumbago of the primary strata, no less than the anthracite, might as well have originated in vegetables, as that each of these should owe an independent origin to elementary mineral carbon.'

According to this theory, why may we not hope to find large quantities of workable coal in any formation where we find it in small quantities? For, the same causes that could produce it in thin beds, might reasonably be supposed adequate to the production of large masses. Anthracite is found in almost every rock from lias to gneiss; and bituminous coal occurs in the oolitic and new red sandstone series, as well as in the proper coal measures.† True, so far as we yet know, the coal measures contain the principal deposites of the latter species in Europe; and perhaps in this country: though I do not admit that our bituminous coal fields have yet been certainly identified with those in Europe. But who knows whether the circumstances under which our new red sandstone was deposited, might not have been such as to produce extensive masses of coal? This would not constitute so great a difference between our new red sandstone and most of that in Europe, as the almost entire absence in the former of gypsum and rock salt; minerals which, on the eastern continent, are regarded as eminently characteristic of this formation. In Yorkshire, England, coal has been found in the new red sandstone: and on the European continent, as in Poland,‡ occasionally in thin seams: and it has been recently ascertained, that the Brora coal field in Scotland, which is probably the equivalent of that of Tecklenburg —Lingen, in Prussia, is contained in the lias;‖ a formation which lies above the new red sandstone: and, therefore, every presumption is in favor of finding coal in the new red sandstone; since this lies between the lias and the real coal measures. This conclusion is still farther strengthened by the fact, that Humboldt, Daubuisson, and other able geologists, consider the red sandstone group, and the coal measures, as belonging to the same formation.* All these facts prove, it seems to me, that it was a hasty generalization which limited workable coal to the coal measures; and that, therefore, we should not be prevented from searching for coal in the new red sandstone of the Connecticut valley.

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* System of Geology, &c. Vol. I. p. 298.

† See Brongniart's Tableau de la Succession at de la Disposition des Terrains et Roches, &c. Paris, 1829. Also, Conybeare and Phillips's Geology of England and Wales, Vol. I. p. 329. Al. Brongniart also describes, as occurring in the Plastic Clay Formation of Mount Meissner in Hesse, 'a true anthracite—that is to say, a dense carbon without bitumen, sometimes with a dull, sometimes with a shining fracture. We here find a thicker bed of compact, solid, bituminous carbon, having a nearly straight fracture, burning with facility, and presenting many of the characters of true coal.'—Phil. Mag. Vol. II. N. Series, p. 108.

‡ Conybeare's Report on Geology, (1832) p. 390.

‖ Philosophical Magazine, Vol. II. N. Series, p. 101.

The coal in this rock occurs in the form of thin beds and irregular nodules, which are rarely but a few inches in diameter. In almost every instance, it appears to be the result of the carbonization of a single plant, whose form can be distinctly traced; though it is always broken into fragments, whose length rarely exceeds two feet. At Whitmore's ferry, in Sunderland; in the north part of South Hadley, and on the north bank of Westfield river in West Springfield, the coal is highly bituminous: though least so at the last named locality. But at Turner's falls, in Gill; at the Southampton lead mine, and at Enfield falls, (Connecticut,) it is anthracite. At the junction of this same formation with the greenstone at Berlin, in Connecticut, Dr. Percival has described a vein of bituminous coal penetrating the greenstone. He says, however, that 'it more usually has the appearance of cinders so mixed up with siliceous matter as to be hardly combustible.'

It becomes an interesting inquiry, whether local circumstances will enable us to explain why the coal at some of these localities is bituminous, and at others anthracite. 'We know,' says Prof. Al. Brongniart,† 'that the coal which is in contact with the veins or dykes of basanite, or trap, that traverse it, and that which approaches masses of porphyry, is less bituminous than other portions of the bed, and that it even loses all its bitumen, and in passing to the state of anthracite, exhibits, as it were, a kind of vitreous texture, &c.' Few geologists will now doubt but the proximity of granite produces a similar effect. Now at Turner's falls we know that a large mass of trap is not far from the coal; and at Southampton, that granite is still nearer; and hence we should expect the coal at these places to have lost its bitumen. I am not aware, however, of the proximity of either of these rocks to the coal at Enfield falls; though ignorant of its particular location. At Sunderland and South Hadley the trap is so far distant, that we are not surprised to find bitumen. The existence of bituminous coal, however, in the trap at Berlin, Ct. is quite remarkable; and the fact that a portion of it is converted into pseudo-cinders, proves that heat does not necessarily drive out the bitumen. The contorted condition of the strata at the locality of coal in West Springfield, renders it quite probable that trap rock exists a short distance beneath the surface. The pretty uniform dip of the strata, where they are laid bare in that town several miles in width, by Westfield river, is from 15° to 20° east. But at the spot just referred to, we find the anomaly which is here sketched.

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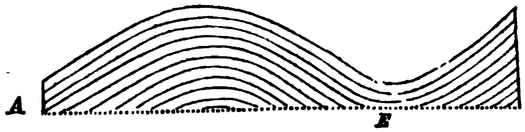
* De la Beche's Geological Manual, 2d Edition, (London, 1832.) p. 405.

† Tableau des Terrains, &c. p. 283.



It is a satisfactory explanation of this case to suppose that greenstone, or some other igneous rock, has pressed upwards with such force between *A* and *E*, as to give to the strata a saddle shaped appearance for a few rods. (Four rods from *A* to *E*.)] If this hypothesis be correct, we can hardly conceive, as in the case at Berlin, why the bitumen is not expelled from the coal. Upon the whole, the cases that have been mentioned, show that something more than mere proximity to rocks of igneous origin, is necessary for the conversion of bituminous coal into anthracite; although heat is undoubtedly the principal agent.

Generally the coal that has been described, occurs in a gray coarse micaceous sandstone. But at the locality at West Springfield, it is found in bituminous marlite. At Sunderland, it is in bituminous shale.

Lead, Zinc, and Iron.

The sulphurets of these metals occur in a vein at the junction of the greenstone and this formation, in Berlin, Ct. as described by Dr. Percival. Galena and Blende, I have observed in small quantities in the fetid limestone of West Springfield, at Paine's quarry, and blende at Meachem's quarry. Sulphuret of iron is quite common in the shale every where. Nodular argillaceous iron ore also occurs in the same rock, at Turner's falls, South Hadley Canal, &c. The carbonate of iron at Turner's falls, has been already described: and I suspect No. 241 to be the same mineral from South Hadley Canal: though it resembles cinnabar. But the chemical tests do not indicate the presence of mercury. From its solution in nitro-muriatic acid, prussiate of potash threw down a dense precipitate of the prussiate of iron.

Iron Sand.

Bushels of this substance, highly magnetic, may sometimes be collected on the Montague shore of Connecticut river, 40 rods below Turner's falls. Probably it proceeds from the disintegration of the new red sandstone at the falls. Some of the iron-colored grains are not magnetic enough to be taken up by the magnet and resemble iserine.

Rotten Stone.

This valuable substance cannot probably be regarded as a simple mineral, since in the present case, it is merely fetid limestone that has been partially decomposed by the action of a mass of greenstone in the immediate vicinity; or by some other cause. It is found at Paine's quarry in West Springfield; and in large quantities. Its quality appears to be very excellent; and in an economical point of view, it deserves attention. It is found also at South Hadley Canal, on the West Springfield shore; though of hardly so fine a quality, and in much less quantity. It is not there associated with limestone. (Nos. 217 to 221.)

Fibrous Limestone, or Satin Spar.

The red and black shales, as remarked in another place, on the banks of Westfield river, in West Springfield, contain numerous veins of this substance from an inch to a mere line wide. Sometimes it forms a thin seam between the layers of slate. The same mineral occurs along with the fish impressions at Sunderland. Common calcareous spar exists in these rocks as well as satin spar.

Concreted carbonate of lime is frequently found in this formation. At West Springfield I found it an inch or two thick between the layers of sandstone, near the southern bed of fetid limestone. At the Sunderland cave, it forms small and imperfect stalactites on the coarse conglomerate: and on the same conglomerate, on the east side of mount Toby in Leverett, I found a large quantity of it coating over a perpendicular wall several inches thick. (Nos. 226 to 230.) This had obviously been derived from the conglomerate by water; and it shows that carbonate of lime is more frequent in this formation than one would be led to suspect from its general appearance.

Sulphate of Baryta.

This mineral, as already remarked, accompanies the veins of copper ore in the new red sandstone in most instances, both in Massachusetts and Connecticut. In this State, it is most abundant at the copper veins in Greenfield; where it forms veins from six to eight inches wide.

Sulphate of Strontia.

This mineral occurs in radiated masses upon fetid carbonate of lime in West Springfield. Its specific gravity is about four; and before the blow pipe, it melts and gives a slight tinge of red to the flame.

Sulphate of Lime.

I have already mentioned, on the authority of Mr. E. Davis, that this interesting mineral exists in small quantity on the banks of Westfield river, in West Springfield. I have found it also, in the form of selenite, on gray sandstone at South Hadley Canal, in quite small quantity. These facts are sufficient to encourage farther research after so valuable a substance.

In some of the seams of the fetid limestone of West Springfield, I have noticed thin layers of purple fluate of lime.

It ought not to be forgotten, that in Europe, the new red sandstone group is one of the depositories of salt and gypsum, as well as the rich mines of Mercury in Carniola: nor ought it to be supposed that our new red sandstone has been examined thoroughly enough, to render it certain that the same minerals do not exist here.

It is now also pretty well ascertained, that the diamond mines of Golconda and Panna in India, and those in South America, occur in a conglomerate belonging to the new red sandstone.* And when we consider how easily one might overlook so rare a substance as diamond, observers, I should hope, will recollect this fact in their future examinations of this rock in Massachusetts.

Organic Remains.

In Europe the new red sandstone is rather remarkable for a paucity of organic relics. And the same seems to be true in this country. Enough, however, have been found in this rock in the valley of the Connecticut, to throw considerable light upon the circumstances under which it was produced. And judging from the success which I have had in the few direct efforts which I have made for discovering the fossils of this formation, I predict that subsequent examinations will bring to light many more. Much obscurity, also, rests upon the nature of several of those which I have found, which farther research will I hope remove.

The remains found in this formation are both vegetable and animal. The former I shall first notice.

Those fragments of vegetables which are not uncommon in certain varieties of the new red sandstone, and which present a thin layer of coal, having the general form of the original plant, might have belonged, in some cases to dicotyledonous plants. And their extremely broken condition shows that they were transported from a distance to the places which they now occupy. Mixed with them, however, and much less broken, we find impressions on the shale, in which usually little vegetable matter remains. These are rarely more than an inch, or an inch and a half wide; but No. 252 is more than 4 inches wide, and this is the largest I have met with. These impressions are slightly striated longitudinally: and probably belong to the tribe of fossil plants *Calamites;* possibly to the *Calamites arenaceus* of Adolphe Brongniart.* Yet I have rarely noticed any distinct articulations in the specimens. Not unfrequently a thin layer of coal occupies the place of the vegetable; its surface still exhibiting a striated or furrowed aspect. Indeed, I think it possible that even those specimens that are so much broken, (No. 253) may belong to the same family of plants.

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* Conybeare's Report on Geology, (1832,) p. 395 and 398.

De la Beche mentions that the *Lycopodites Sillimanni*—a fossil plant peculiar to America—is found at Hadley in Connecticut.† No such town exists in Connecticut; and I can have but little doubt this is a mistake for South Hadley, Massachusetts; for I know of some gentlemen in Connecticut, who obtained some years ago, several peculiar vegetable fossils at that place; though I have not been so fortunate. Professor Silliman, who probably sent this fossil to Europe, has no recollection concerning it.

I obtained a single specimen several years ago at Sunderland, and gave a figure of it in the 6th volume of the American Journal of Science, which bears considerable resemblance to the rachis of the *voltzia brevifolia*, when destitute of fructification, as figured by Ad. Brongniart in the 15th volume of the Annales de Sciences, and found in the sandstone formation near Strasburg.

In some of the lowest beds of this formation, (those which have been heretofore called the old red sandstone,) I have lately found in Deerfield and Greenfield, a singular petrifaction, which Dr. Morton says, 'evidently belongs to the fossil genus Fucoides, of which Dr Harlan has described a species from the sandstone of Genesee, New York, under the name of F. Brongniartii. (Amer. Jour. of Geology.) If your specimens were weathered, their specific characters would be more obvious, and would probably prove identical with those from Genesee. Dr. Harlan, however, has used a specific name already in use: for among British fossils, there is a F. Brongniartii enumerated in Woodward's Catalogue, 1830; which species is figured in Mantell's Geology of Sussex.'

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* Histoire des Vegetaux Fossiles, Plate 23. Fig. 1.

† Manual, p. 419, 2d edition.

This Fucoides varies in size from one tenth of an inch to an inch in diameter. More commonly it runs through the rock in a direction corresponding to that of the laminæ; in which case it is considerably flattened. Sometimes it passes obliquely through the layers, and very commonly crosses them at right angles; in which last case it has a cylindrical form. It is rare to see a specimen of any considerable length, that is not more or less curved; and I have never met with one that was branched at all. I have noticed specimens a foot or more in length, and they may be much longer than this, since I have not met with any large mass of rock containing them. The sandstone in which they are found is rather fine and quite soft, and easily disintegrates. They occur near Hoyt's quarries, one mile west of the village of Deerfield; and also a few rods south of the county jail in Greenfield, close by the stage road.

The vegetable matter in these remains is wholly replaced by sandstone. By breaking the specimens transversely, a curious structure is revealed. It may be described, by saying that the cylinder is made up of convex layers of sandstone, piled upon one another: and I observe that in the same rock all the specimens have the convex side of these layers in the same direction; so that on one side of the rock you will see numerous button-like protuberances, and on the other side corresponding concavities. (No. 258.) But I do not know which side is uppermost in the rock, in situ. Nor am I familiar enough, either with living or fossil agamous plants, to know whether there is any thing remarkable in this structure.

An examination of the species of Fucoides described by Dr. Harlan, has convinced me that the one now under consideration is not the same. However much the latter is weathered, it never presents that distinct appearance of articulation which gives to Dr. Harlan's species so much the aspect of an encrinite. His species is also often distinctly branched; ours, so far as I have observed, never. And even if they are identical, Dr. Harlan's specific name must be abandoned because already applied to another species. Under these circumstances, I venture to denominate this species, *Fucoides Shepardi;* as a mark of respect for my friend Mr. Charles U. Shepard of New Haven, whose claims to such a notice, every naturalist, who has read his productions on Natural History, will be ready to acknowledge.

Plate XIII. figs. 38 and 39 are sketches of two specimens of this Fucoides.

Fossil Trunk of a Tree.

I saw this interesting relic several years ago, in Dr. Smith's collection in Southbury, Ct. It was obtained in that place in the sandstone formation extending from Woodbury to the Housatonic; which, although separated topographically from the new red sandstone of the Connecticut valley, appears to possess precisely the same characters. The specimen to which I refer was cylindrical, eight or ten inches in diameter, highly siliceous, and exhibited the bark very distinctly; which if I do not misrecollect, was carbonaceous. It was discovered in a swamp, and a laborer, mistaking it for a stump of a recent tree, struck it with his axe; and being vexed at the injury his instrument received, he in revenge broke it almost to pieces. The unbroken fragment in Dr. Smith's possession, however, was several inches long.

The circumstances above related, render it probable that this trunk, when first discovered, stood in the position in which it grew; as has been found to be the case in numerous instances in the sandstones of Europe.

Animal Remains.

About thirteen years ago, an interesting discovery of the bones of an animal was made in digging a well near Ketch's Mills, in the east parish of East Windsor, Ct. The rock is a red conglomerate, belonging to the higher part of the new red sandstone, and exceedingly resembles in color and hardness the conglomerate of the lowest beds. The workmen penetrated five feet of soil before reaching the rock, and then blasted the latter to the depth of eighteen feet, before reaching the bones. And although little care was taken to obtain these in a proper state for examination, and they were mostly scattered among visitors to the spot, yet the following facts may be depended on.

The most remarkable fact is, that these bones were not at all mineralized; but retained the color and other characters of bones that have long been buried. On exposure to the air, they were much disposed to crumble down. Yet this was not universally the case, as two or three small fragments, still in my possession, testify. These bones belonged to a vertebral animal, about five feet long, which lay horizontally in the rock; and as the caudal vertebrae were quite numerous, projecting in a curve eighteen inches beyond the body of the skeleton, I suspect these bones belonged to a saurian animal; especially since such animals have been found in the new red sandstone in Europe.

Having understood that an individual in East Windsor, (for his own sake I will not mention his name,) had preserved several fragments of these bones, and finding that geologists abroad were beginning to doubt whether any such discovery had been made, I travelled seventy miles, accompanied by an artist, in the hope of being allowed to take sketches of the specimens. But I was not permitted even to look at them. I tried to console myself under so unexpected a disappointment, first, by reflecting that I had not received such treatment any where else; and secondly, by repeating the sentiment—*parvum parva decent.*

Ichthyolites.

The remains of fish have been found on bituminous shale and bituminous marlite, in Middletown, Ct. at Sunderland Mass. and also in West Springfield and Deerfield. Sunderland, however, is the only spot where they can now be procured. The shale there forms the bank of the river several feet high: but the ichthyolites are most abundant in the lower part of the bed, which corresponds nearly with low water mark. I have dug out hundreds of specimens at this spot; though perfect ones are very rare to be obtained. On one layer of the rock, fifteen inches by three feet, seven distinct impressions were visible. Indeed, I have not unfrequently met with one fish lying across another, without the intervention of a layer of shale: and from these specimens, I can easily conceive how the mistake should have been made, that among the Monte Bolca ichthyolites, one fish was found in the act of swallowing another!

A thin layer of carbonaceous matter usually marks out the spot where the fish lay; except the head, whose outlines are rendered visible only by irregular ridges and furrows. In some cases, however, satin spar forms a thin layer over the carbonaceous matter, and being of a light gray color, it gives to the specimens an aspect extremely like that of a fish just taken from the water.

We sometimes find the specimens a good deal mutilated; so much so, indeed, that the form of the fish is entirely lost: and the scales and fins are scattered about promiscuously: and this too in the vicinity of other specimens that are entire. Hence we cannot impute this mutilation, as is usually done, to a disturbing force acting on the rock at the time in which the fish was enveloped, or afterwards. But if we suppose that the fish, as they died, were gradually enveloped by mud, it is easy to conceive how some of them might have putrified and fallen to pieces, before they were buried deep enough to be preserved: or it might be that the fish was mostly devoured by some other animal; and in either of these ways, we might expect to find only scattered relics enveloped in the rock.

The great resemblance of these ichthyolites to those found on the bituminous slate of Mansfield, in Germany, has been already noticed. Probably all of them belong to the genus Palaeothrissum. I am inclined to believe that I have found four species. Plate XIV, Figs. 45 and 48, are probably the same species: the outlines of the latter being sketched, merely because they are more distinct than those of Fig. 45. Forty nine fiftieths of the specimens at Sunderland belong to this species. Fig. 46 is a smaller species; differing very decidedly from the first, but very rarely met with. Fig. 44 is still smaller: the scales being minute; and I have found only one specimen of it. The fish in this case, as may be seen by the drawing, appears not to have lain upon its side, as they generally do, when it was enveloped in the rock. There is occasionally found a specimen of greater length than any which are sketched; and yet the scales are smaller than those on Fig. 45: I suspect this to be a fourth species: but I have no specimen sufficiently perfect to permit a drawing to be taken.

Mollusca.

The only molluscous animal which I have detected in the new red sandstone formation, was found in rolled masses in Amherst; and the only specimen at all distinct, is sketched on Plate XI, Fig. 17; and belongs to the College collection in that place. Although much broken, there can be little doubt but it is an *orthocera*. For a long time I supposed the rock containing this mould, was a wacke-like trap: but I am now satisfied that it is a micaceous sandstone, more indurated than is common. I should not be surprised if it should hereafter appear, that the vicinity of Turner's falls is the spot from which this specimen originated.

At those falls I obtained the specimen No. 282, on whose surface are some protuberances that much resemble a univalve shell: but they may be concretions.

Zoophyta.

Under this head I introduce a remarkable organic relic, which I recently discoverd on the brown shale, or rather fine micaceous sandstone, on the banks of Westfield river, (generally called Agawam river near its mouth,) in West Springfield. It is characterised by grooves and correspondent ridges, which sometimes ramify, and by small somewhat polygonal reticulations, which cover the entire surface of the shale as far as the grooves extend. (Nos. 264, 265.) These reticulations are rarely more than one quarter of an inch in diameter, and they diminish in size as we approach one extremity of the impression. No animal or vegetable matter remains upon the shale, yet the grooves and the reticulations are quite distinct. Plate XIII, Figs. 34 and 35, are sketches of this organic impression; the latter showing the diminution in size of the net work, towards one extremity. The reticulations and grooves are of the natural size in both figures.

I found this impression on the north bank of Westfield river, in the west part of West Springfield. The shale containing it passes on one side under the river; the impression still continuing in that direction, as far as the rock could be examined. On the other side, that is, northerly, I found it to extend eleven feet, and at least two feet in width; nor did the margin of the specimen appear in any direction. More recently the spot has been visited by Solomon Lathrop Esq. of West Springfield, who has uncovered the impression eighteen feet in length, and at least four feet in width. Towards the north, he found the reticulations to become finer, until at length the impression ceased to appear in that direction; but how much farther it extends under the river, he could not ascertain. And he says, 'how much wider the impression is (than four feet,) I cannot tell, but should presume several feet.' Thus we ascertain the existence of an animal or vegetable relic, at least eighteen feet long and four feet wide! and it may occupy twice or thrice that extent!

But which is it, animal or vegetable? I have searched in vain for any thing resembling it in Brongniart's *Vegetaux Fossiles*, in Parkhurst's Organic Remains, and in all other descriptions of a similar kind, within my reach. But the reticulations certainly bear a strong resemblance to those on some existing species of Gorgonia, or *sea fan;* to the G. reticulata, for example, as figured in Rees' Cyclopedia: although in this species we see nothing that could have produced the grooves so obvious on the fossil. The fossil Gorgoniae, also, as figured by Goldfuss, especially the G. *ripistena* and *infundibulformis*,* bear considerable resemblance to the impression from West Springfield: but these species are only an inch and a half long. Yet some of the existing species 'in deep bays, and similar situations of the sea, no less favorable to their growth and increase, attain to the gigantic height of ten or twelve feet; and from their number as well as magnitude; their remarkable ramose, and foliated or flabelliform appearance; interwoven structure, or coral-like texture, form a conspicuous portion of those vast sub-marine 'groves of coral' that are sometimes seen by navigators in the hotter regions of the globe.'†

Upon the whole, I am strongly inclined to believe that this interesting relic must have been an enormous Gorgonia. True, no discovery has yet made of the central stem: but who knows that the shale has yet been explored far enough in width to discover it. If so, this specimen may yet be found to be from eight to ten feet in width! ‡

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* Petrifacta, Plate VII, fig. 2, and Plate X, fig. 1.

† Rees' Cyclopedia, Art. Gorgonia.

‡ While the proof sheet of this page for the first edition, was under examination, I received, through the kindness of Professor Silliman, Mr. Witham's 'Observations on Fossil Vegetables,' Edinburgh, 1831; and his 'Description of a Fossil

No one, who admits this fossil to be a Gorgonia, will doubt, I think, that it is an undescribed species. I therefore take the liberty to dedicate it to Dr. C. T. Jackson of Boston, under the name of *Gorgonia Jacksoni.* This I do without any personal acquaintance with Dr. Jackson, in testimony of my respect for his attainments and productions in geological and mineralogical science.

Plate XIII, Fig. 36, is a sketch of an impression found in the same shale, only an inch or two higher up in the rock. (No. 256.) It scarcely differs from the others, except in the absence of the the reticulations. Mr. Lathrop, who sent me this specimen, could discover none of these. But I have noticed that frequently the reticulations are attached to a very thin layer of shale, which easily cleaves off and leaves an impression precisely like that in the figure. Hence I suspect that these reticulations will be found connected with the grooves: although I can easily conceive of different species in which the net work should be absent. And Mr. Lathrop says, that such as are represented in the figure are quite abundant, not only at the spot mentioned above, but also half a mile nearer the village of West Springfield, where he says, 'the leaves are larger, and in one instance the edge appeared serrated.'

On the surface of the same shale, along the same river, we find irregularly ramified masses of flint, or silceious slate, from half an

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Tree in the Quarry at Craigleith,' Edinburgh, 1833; and I was at once struck with the resemblance between several of the drawings in those works, and those which I have presented of the fossil described in the text. But Mr. Witham's drawings represent sections—mostly transverse—of fossil trees as seen through the microscope; and therefore, the specimens from which they were taken, cannot be remotely allied to the fossil at West Springfield, which consists simply of an impression upon shale.

The botanist will also notice a resemblance between the drawing of the fossil described in the text, and a drawing of the bark of the *Xanthorhœa hastilis*, in Decandolle's 'Organographie Vegetale.'[*] But the latter exhibits only the inner side of the bark, which would not be shown in a fossil state; and it is clear from Plates VII and VIII of that work, that the whole trunk of the Xanthorhœa would present a very different appearance in a fossil state, from that of the West Springfield relic.

Professor Silliman has kindly given me his opinion in respect to the character of the sandstones in the Connecticut valley: and I shall take the liberty to insert it here. It will be seen that there is no real discrepancy between us on the subject. He is more confident than I am of the existence of the old red sandstone in this valley; while I merely say, that I have not evidence enough of its existence to justify me in marking it on the Map. Professor Silliman, I trust, will excuse the liberty which I take in copying his opinion from a private letter, since it is the opinion of one who examined this subject much earlier than myself, and who, in my earliest as well as latest geological pursuits, I have always regarded as my counsellor, patron, and friend.

'My impression is,' says he, 'that both the old and the new red sandstone exist in the great formation of Massachusetts and Connecticut: that the old lies the lowest, and is palpably (at least here) granite ruins: that the new lies higher in the series; and that the coal formation may come between them as elsewhere.'

[*] Plate VIII. Fig. 6, (Paris, 1827.)

inch to an inch in diameter. I could not resist the impression that this siliceous matter may have taken the place of a zoophyte: although I have seen no certain evidence of organization. (No. 267.) But if the specimens that have been described are Gorgoniae, we have certainly presumptive evidence that other zoophytes would be found in the same rock.

Radiaria.

Under this name I have a specimen, perhaps still more remarkable than the last, to introduce. It is from the fetid limestone in West Springfield. Plate XII, Figs. 29, 30, 32 and 33, are intended to convey an idea of the most important varieties of this petrifaction, which I have hitherto discovered. Fig. 33 exhibits its most common form. This is composed of cylindrical bodies, usually less than half an inch in diameter, and several inches long, running in a parallel direction through the limestone. On breaking them transversely, they are seen to consist of concentric layers of carbonate of lime, of various shades of color: the outside of the external layers (and, indeed, more or less so of the others,) being covered with small warty protuberances; but showing no marks of transverse septa. Not unfrequently a small perforation occupies the centre of the cylinder; and at other times it is occupied by calcareous spar, which probably entered by infiltration. A radiated structure is generally quite obvious: especially when specimens are newly fractured crosswise. (Nos. 268 to 277.)

Fig. 32 exhibits one of these cylinders, terminated by a spheroidal head, and covered over with the warty protuberances that have been mentioned.

Sometimes these cylinders enlarge and several of them (frequently three) become united, so that the outer layers enclose the whole: as is shown in Fig. 30.

In one or two instances, numerous small cylinders become united in this manner, and form a rather confused mass in the centre, surrounded, however, by distinct layers. In this case great enlargement takes place, as in Fig. 29. The lower part of that specimen, which cannot be seen in the sketch, exhibits numerous small and distinct tubes, which by extending an inch or two, become blended in the confused mass that occupies the central parts, as seen on the upper surface in this figure.

The appearance of a concretionary structure is so marked in some specimens, that one or two geologists, for whose opinions I entertain a high respect, have even suggested whether this remarkable substance be a real petrifaction; and inquired whether it may not be of a nature similar to the columnar limestone, described by Capt. Bonnycastle with a plate, in the 20th volume of the Am. Journal of Science. Judging from the plate, as well as specimens which I have seen of that limestone, I am satisfied that the specimens from Springfield are of a very different character, and exhibit far more marks of organic structure. Indeed, I can hardly doubt but they are real petrifactions; but having examined Goldfuss' Petrifacta, Miller's Crinoidea, Sowerby's Mineral Conchology, Parkinson's Organic Remains, &c., I can find no fossil resembling these. The new genus Marsupites of Mantell* does indeed, bear some resemblance to that under consideration; but they are probably different. General analogies only, have led me to regard them as having resulted from the petrifaction of radiated animals: though I am by no means sure that they are not of vegetable origin.

The specimens, Nos. 263 and 265, were obtained from the shale that forms the north bank of Westfield river, in West Springfield: and from their general aspect, I suspect them to be Encrini: though they may be of the same nature as the remains just described. The mineralizer in this case seems to be argillo-ferruginous limestone, except the central part.

Whether the Nos. 283, and 284, are to be regarded as organic relics, I feel unable to decide.

Theoretical Considerations.

The new red sandstone series that has been described, consisting chiefly of the fragments of older rocks from the surrounding region, must obviously have been produced chiefly by the agency of currents of water, which first wore away these rocks, and then transported and deposited the fragments where we now find them. By what agent or agents their consolidation was effected, we may not be able, perhaps, in the present state of geological science, to determine. We do know, however. that water, air, and heat, may all, under certain circumstances, accomplish this work. Water may contain in solution some cement, say carbonate of lime, which shall be deposited in the interstices between water-worn fragments and thus unite them. Air, it is also well known, by abstracting water from some of the materials that form rocks, does sometimes effect their consolidation. Heat, likewise, in the same manner, if it be sufficiently powerful, by producing also a crystalline arrangement of the materials, will harden them into stone. Now in the case of the red sandstone, all these causes may have conspired to effect its consolidation. The existence of beds of limestone in this formation, and of carbonate of lime diffused through some of the varieties of the shale, and even of the coarse conglomerates, shows that deposition from chemical solution in water, was one of the important agencies concerned in its production. The inclined position of the strata, as well as the character of the organic remains, show that these rocks have been elevated from beneath the water, and of consequence have been, at least in part, hardened by dessication. And the presence of trap rocks in the midst of the formation, not to speak of other proofs of igneous action, demonstrates the agency of heat in its consolidation.

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* Geology of the S. East of England, (London, 1833,) p. 114.

It will naturally be inquired, how the red color, so characteristic of the most important varieties of this rock, could have been produced. Undoubtedly it proceeds from the red oxide of iron, which, in some way, has been diffused through the mass. But whether heat or water was the agent employed, may be doubtful. We find in breaking open the fragments in the conglomerates, that the smaller ones are penetrated throughout by this coloring matter; while the larger ones are colored only to a certain depth. (See No. 143.) Now, has the iron actually penetrated these nodules, or has water or heat changed the iron, which they originally contained, into the peroxide? The latter supposition appears to me most probable: and though air and water might possibly produce such a change to some extent, yet I think we must call in the agency of heat to explain the very thorough manner in which some of the finer sandstones of this group have been colored red. For I doubt whether air and water can do much in this process, unless they also produce incipient decomposition.

In another place I have advanced an hypothesis to explain the manner in which such sudden and numerous alternations of the coarsest and the finest materials in this rock may have been produced: viz. by the flux and reflux of mighty deluges, caused by the elevation of mountain chains in various parts of the globe. Some of these waves may have resulted from the elevation of the strata of the older rocks on which the sandstone rests unconformably; for the strata of the former are much nearer to verticality than those of the latter; and, therefore, must have been raised before the deposition of the sandstone, at least to some extent. In some cases, however, there is reason to believe that the abraded fragments were transported southerly. Thus, the conglomerate in Greenfield and Bernardston, near the argillo-micaceous slate, out of whose ruins it was obviously formed, (Nos. 137, 138, 139,) lies south of the parent rock; though a stratum of the slate might once have extended farther south than at present, and have been worn away by the powerful reflux wave which rushed easterly, when the Hoosic range of mountains was elevated. The fragments of the conglomerate of mount Toby and in Montague, correspond somewhat with rocks found several miles to the north, within the limits of Vermont and New Hampshire:

though it must be admitted that these rocks also, might once have extended farther to the south than they now do.

It is an interesting inquiry, whether the greenstone ranges now existing in the very midst of the sandstone formation, were produced anterior to that rock, or during the same epoch, or afterwards. In all the lower beds of the sandstone formation, I have never found a single fragment of the greenstone; and, therefore, I infer that the latter rock did not exist previous to the deposition of these beds. Nor have I found any of the trap in the conglomerates of the higher beds, except a narrow stratum, which I have described under the name of trap conglomerate: and which lies in immediate contact with the greenstone of Tom and Holyoke, so as rest upon it. Greenstone must, therefore, have existed in the vicinity, before the formation of this conglomerate; and there is only one difficulty in supposing the whole of the greenstone in the Connecticut valley to have been produced immediately subsequent to the deposition of the lower beds of the sandstone. From some facts to which I have already alluded, and which I shall describe more particularly in speaking of greenstone, it would seem that the upper beds of the sandstone, those that lie even higher up in the series than the trap conglomerate, have been disturbed and elevated by the intrusion of the greenstone. Hence I should infer, that the greenstone continued to be produced, until nearly all the beds of sandstone had become consolidated: and that probably the existing trap ridges were the last erupted. From all these facts, then, I infer, that greenstone began to be erupted not far from the middle of the epoch of the deposition of the sandstone; and continued to be thrown up at intervals, during the remainder of the period in which the sandstone formation was advancing to its completion.

I have assumed it as a fact, that the sandstone formation under consideration was deposited beneath the ocean, and subsequently elevated. The proof is quite conclusive. Imperfect as is the account which I have been able to give of the organic remains in this group, it contains enough, I think, to settle this point. To whatever species the Fucoides that occurs in the lower beds may be referred, we may be sure that it was a marine plant. For, says Adolphe Brongniart, 'these plants (the Algae, including the Ulvaceae and Fucoideae,) grow almost without exception in salt water; certain Ulvae only being able to develope themselves in fresh water.'* This opinion is still farther confirmed by what that same writer says of the species of Fucoides found in the new red sandstone of Mansfeld, in Germany, including of course the bituminous marlite. 'Out of seven species,' he says, 'five to all appearance, belong to two genera which best characterise marine vegetation in the torrid zone.'* If the reticulated fossil, which I have described, be a real Gorgonia, as I suppose, it furnishes another conclusive proof of the marine origin of this formation: for this animal is exclusively marine. As to the fishes found in the shale of this formation, Brongniart says, that 'many of them may be referred to genera living commonly in fresh water: but others are generally marine;' and he infers from the other fossils that occur in the same rock, that it was deposited in salt water. Concerning the Palaeothrissum, the only genus of fishes yet found in our sandstone, as no similar fish is now known to exist on the globe, we cannot say whether it was an inhabitant of fresh or salt water; except that the other remains found in connection with this, so far as we know their nature, are marine: and, therefore, we infer that this fish was so too.

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* Histoire des Vegetaux Fossiles, I. Livraison, p. 37.

This conclusion corresponds with those that have been made in other countries, as to the new red sandstone group. Every where it is found, when carefully examined, to have had a marine origin; though some members of the series do contain fresh water remains, or those of land animals, or vegetables; and hence they are sometimes called fluvio-marine: that is, they were formed in estuaries, or shallow seas, into which the organic products of the land and fresh water were occasionally borne by rivers. But in the new red sandstone of the Connecticut valley, no animal relic has yet been found, which is decidedly of fluviatile, lacustrine, or terrestrial origin; although a part of the vegetable remains (the Calamites,) undoubtedly grew upon dry land and in a tropical climate.

It is certainly an interesting thought, that this delightful valley, which now forms so charming a residence for man, once constituted, and for an immense period, the bottom of a tropical ocean, where gigantic Gorgoniae, certainly 20, and perhaps 40 feet high, formed coral groves, and Fucoideae more numerous, flourished. The astonishing change brought about in the course of ages, exalts our conceptions of the wisdom and extent of the plans of the Deity; and leads us to anticipate future changes, whenever those plans require.

I have said that it was a tropical ocean. I mean that its temperature was much higher than that of the ocean which now washes our shores. For otherwise, how could sea-fans, larger than any which our tropical seas now produce, have been sustained. The fact that in early times, while the secondary rocks were depositing, the climate in high latitudes must have been much warmer than at present, is, indeed, so completely established by researches in other parts of the world, that it would be strange if we should not find the same thing to be true on this continent. But the few facts which I have detailed, that throw any light on this inquiry, all tend to show that there is no exception here to the general law. New England certainly had a tropical climate when the ocean that deposited the new red sandstone stood over it. And Adolphe Brongniart says, that two species of Fucoides, found in the limestone of Canada, approach very near to a genus of these plants that now grows only in tropical seas: a fact that tends to corroborate the views which have been presented relative to the new red sandstone of the Connecticut valley.

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* Hist. des Veg. Fos. p. 43

A careful examination of the fossils of this sandstone, will convince any one that their resemblance to any now found living on the globe, is very faint: so that probably they cannot be referred to the same genera, much less to the same species. This too accords with the facts that have been observed in other parts of the world. The farther down in the series of rocks we penetrate, the more unlike living animals and plants are those found in a fossil state. And it seems to be now pretty well established, that there have been several successive creations and extinctions of animals and plants on our globe, before the production of its present organized beings. It is not certainly ascertained how many of these destructions and renewals have taken place. Adolphe Brongniart thinks that four changes of this kind are clearly discernible among fossil vegetables.* Hence he infers, that there have been four periods of vegetation since the creation; each differing from the other by a marked distinction in the species, and even genera of plants, and in the numerical proportion of the different kinds. During the first period, the strata, from the lowest fossiliferous rocks to the lower part of the new red sandstone, were deposited. The second period includes the time during which the new red sandstone series was forming. During the third period, the vegetables lived, which are found between the new red sandstone group and the chalk, including the latter. The fourth period commenced after the deposition of the chalk, and reaches to the highest of the tertiary deposites. During each successive period, the vegetation becomes more perfect; that is to say, vascular cryptogamian plants predominated vastly during the earlier periods, while dicotyledonous and monotyledonous vegetables prevailed during the last period. The same is true in respect to animals. Those found in the lowest rocks are extremely simple in their organization, and vertebral animals, except perhaps a few fishes, do not appear lower down than the new red sandstone; while land animals begin to appear still higher in the series.

The conclusions of Dr. Macculloch appear to coincide nearly with those of Brongniart: and the former writer takes animals as well as vegetables into the account. 'Thus then,' says he 'if these views are correct, I have demonstrated four extinctions of antecedent organized creations: while there are two more perhaps less satisfactorily proved.'* He seems to be disposed afterwards to raise this number to seven, or even eight, including man and the existing race of animals.

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* Dictionnaire D'Histoire Naturelle, Art. Vegetaux fossiles

Sir Charles Bell, the most distinguished anatomist in Great Britian, regards the great difference between the living and the fossil animals, and between those in successive groups of rocks, as decisive evidence of new creations. The principles of comparative anatomy, he considers as proving this beyond all reasonable doubt. 'Every thing,' says he, 'declares the species (of animals) to have its origin in a distinct creation, not in a gradual variation from some original type; and any other hypothesis than that of a new creation of animals suited to the successive changes in the inorganic matter of the globe—the condition of the water, atmosphere and temperature—brings with it only an accumulation of difficulties.'†

Recent discoveries in astronomy render it probable that there exist disturbing forces among the heavenly bodies; very feeble, indeed, but which must, after periods of immense length, produce important and extensive changes and catastrophes among suns and planets. And one cannot but inquire, whether there may not be some kind of connection between these astronomical and geological periods. But we ought to recollect, in the language of Professor Whewell, that 'our knowledge of the vast periods both geological and astronomical, of which we have spoken, is most slight. It is in fact little more than that such periods exist, that the surface of the earth, has, at wide intervals of time, undergone great changes in the deposition of land and water, and in the forms of animal life; and that the motion of the heavenly bodies round the sun are affected, though with inconceivable slowness, by a force which must end by deranging them altogether. It would, therefore, be rash to endeavor to establish any analogy between the periods thus disclosed; but we may observe that they agree in this, that they reduce all things to the general rule of finite duration.'‡

It ought not, however, to be forgotten in this connection, that not a few of the disclosures of modern astronomy give us reason to believe, that some of the heavenly bodies are now in that semi-chaotic condition, in which they are unfit residences for such nature as ours, and are in fact in a state similar to that in which the earth was for ages previous to the creation of man; that is, slowly passing from a desolate to a habitable condition. The comets appear to be in the extreme of desolation, even in a gaseous state, demanding periods incalculably long, by the operation of natural laws, for their consolidation, and conversion into fit abodes for animal and rational natures. Possibly still farther removed from such a state, may be the nebulae. The moon appears to be so far redeemed from the uncontrolled violence of volcanoes, as to be adapted perhaps to some animal natures. Jupiter is not improbably still covered by one wide ocean, in which such monsters as our secondary strata disclose, may now have sway. In short, astronomy has disclosed enough of the geology of other worlds, to render probable the conjecture, that they are undergoing those astonishing changes, which seem to have taken place, or to be now progressing, within and upon our own.

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* System of Geology, Vol. II. p. 432.

† The Hand, its Mechanism, &c. p. 115.

‡ Whewell's Bridgwater Treatise, p. 157.

I am aware that such conclusions as these will seem to many at variance with the sacred record. For Moses speaks only of one creation of plants and animals. But if it be only admitted, as it seems to me the principles of a just interpretation demand, that after mentioning the original production of the universe out of nothing, he leaves untouched an indefinite period, of what may be called the semi-chaotic state of the globe, we shall find no difficulty in reconciling every apparent discrepancy. For during this long period, all those creations and revolutions which the strata now reveal, may have taken place; and the animals and plants thus brought to light, are of exactly the character which we should expect might exist in a semi-chaotic condition of the globe. But of what possible use, in a moral point of view, and in a revelation for the great mass of mankind, would it have been, to have given an account of the creation and extinction of certain huge ferns, sea weeds, zoophytes, and sea monsters, whose relics would be brought to light, not till several thousand years afterwards, by the researches of geologists?

That the first chapter of Genesis admits of the interpretation which I have suggested, is rendered probable from the fact that commentators of no mean name had adopted it long before geologists had suggested the difficulties that have been mentioned. Bishop Patrick, for instance, more than 200 years ago, is full and explicit on the subject in his Commentary. Not a few of the distinguished commentators and theologians of our own days have advanced the same opinion. Suffice it to mention the names of such men as Bishops Horsley, Sumner, and Gleig: Dr. Chalmers, Dr. Buckland, Professors Rossenmuller, Conybeare, Whewell, Jameson, Sir Charles Bell, Sir J. F. W. Herschel, Sharon Turner, &c.

So far then from finding in these facts and conclusions of geology any objections to the Mosaic records, I find in them a striking evidence of the benevolence of the Deity. For during the long period above spoken of, the globe was evidently preparing for the residence of man, and the other animals that now inhabit it. Before their creation, its temperature was too high, and its surface too liable to be broken up by volcanoes and drenched by deluges, to be a secure and happy abode for the more perfect races of animals that now inhabit it. But it was adapted to the nature and habits of such animals and vegetables as we now find entombed in the rocks. The overflowing benevolence of the Deity, therefore, led him to place such beings upon it; and thus to communicate a vast amount of happiness, which seems to be a grand object in all his plans and operations. The vegetables that existed in those early periods, have been converted, in the course of time, into the various species of coal now dug from the bowels of the earth; while the remains of the animals of those times have become changed into limestone. And even those violent volcanic agencies, by which the successive races of plants and animals have been suddenly destroyed, have probably introduced into the upper part of the earth's crust, various metallic veins very important to human happiness. And in all this, we see indications of that same benevolent foresight and care, for supplying the wants of his creatures, to which our daily individual experience of God's goodness testifies.

I deduce another moral consideration of no little importance, from the facts and conclusions that have been stated. So constant and uniform are the operations of nature in general, that philosophy has always been prone to regard the universe as a most curious machine, set in motion at the beginning by an all-wise being, who having furnished it with every thing requisite to keep it eternally in play, has left it to run on in the prescribed course, without his interference, and without any need even of his direction and superintendance. Indeed, some have thought this machine so perfect, as to need no creating and superintending Cause, if we only admit it to have been eternally in motion. But these records of geology show us that this supposed uniformity has been often broken in upon. For if the geologist can explain how the operation of natural laws might destroy races of plants and animals, he must admit a special miraculous interference in the creation of new ones. The resemblances between the plants and animals in each of the divisions of the strata, that have been mentioned, even to the very limits of each division, and the suddenness of the change that then takes place in their characters, preclude the idea, so much of a favorite with certain philosophers, that all was the result of a gradual metamorphosis. Now if we thus ascertain that God has specially interfered with the operation of natural laws in the instances under consideration, the presumption is, that he may interfere again, whenever the good of his universe demands. Thus do we get rid of a host of atheistical objections, with which the the student of natural theology finds his path encumbered. It would have been well, if some, who can see nothing but atheistical tendencies in the principles of geology, had recollected, before filling their pages with uncandid vituperation of this science and its cultivators,* that it is the only science, with the exception perhaps of astronomy, whose principles could furnish such a refutation.

Nor ought it to be forgotten that these very principles and deductions of geology, that have excited so much of alarm and opposition among some friends of religion, and so much of premature and groundless exultation among its enemies, have nevertheless, when taken in connection with astronomy, developed and established a law of God's natural government of the universe, grand beyond all others known to man; and undiscovered, or only dimly seen, by the great minds of other generations. I refer to the fact, that *perpetual change is made the grand conservative and controlling principle of the universe.* Men have always seen and felt this instability in respect to every thing on earth: and they have regarded it as a defect, rather than a wise law of the natural world. But they now find it to be equally true of suns and planets, as of plants and animals. 'Perpetual change, perpetual progression, increase and diminution, appear to be the rules of the material world, and to prevail without exception.'† And this very instability is the great secret of the permanence and constancy of nature's operations, and of the adaptation of the external world to the wants and happiness of organized beings. It is 'a principle superior to those grand rules which we have been accustomed to regard as constituting exclusively the laws of nature, from the security which we see in it, beyond the longest and apparently most perfect periodical movements of our solar system.'‡ In fine, it is probably the most splendid display of the Divine skill which the universe can furnish.

I have here entered only upon the limits of a wide field. I cannot proceed farther. The great interest which every reflecting man feels in speculations of this kind, and the expectation of being misunderstood if I entered into no explanation, (should these labors be made public,) have led me to venture thus far.||

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* See Penn's Comparative Estimate of the Mineral and Mosaical Geologies, 2 Vols. 8vo. 2d Edition, London, 1825.

† Prof. Whewell. Bridgwater Treatise p. 158.

‡ Essai sur la Temperature. De l'Interior De la Terre par. M. Cordier, p. 84.

|| The connection between geology and the Mosaical record excites at the present day so much interest, and so much crude matter appears on the subject, that I trust I shall be pardoned for referring to those authors who have treated upon it in our

5. GRAYWACKE.

This term, it is well known, has occasioned much perplexity in geology; and on many accounts, besides its cacophony, it would be well perhaps to expunge it from the science. Yet I could find no term more convenient, as a sort of index, to an interesting group of rocks, partly chemical and partly mechanical in their structure, occurring in several places in the eastern part of Massachusetts. The varieties included in the group are quite numerous; and some of them exceedingly unlike the others in composition and appearance. Among them all it may perhaps be doubted, whether the exact classical graywacke of Werner can be found. But later geologists have given the term a much wider range. 'It designates, when taken in a more general sense,' says Humboldt,* 'every conglomerate, sandstone, and fragmentary or arenaceous rock of transition formation, that is anterior to the red sandstone and coal formation.' 'Viewed on the large scale,' says De la Beche,† 'the graywacke series consists of a large stratified mass of arenaceous and slaty rocks, intermingled with patches of limestone, which are often continuous for considerable distances.' I use the term in 'the general sense' described by Humboldt; and include in it, both the 'graywacke group,' and 'the lowest fosiliferous group,' of De la Beche; though I am not sure that our series embraces any limestone. And since the red sandstone does not occur in the eastern part of the State, nor any other secondary rock, I am not sure that the series under consideration, ought to be regarded as filling up the whole space between the red sandstone and the primary rocks. But every geologist who examines this series, sees at once that some members of it must belong to the oldest of those rocks which some writers denominate *transition.*

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own day. In some of the following works, however, such violent prejudices are manifested, and sometimes such a deficiency of knowledge, respecting practical geology, that the reader need to be well on his guard in their perusal, and to be thoroughly conversant with the facts of the science.

Cuvier's Theory of the Earth: Conybeare's Introduction to the Geology of England and Wales; De Luc's Letters on the Physical History of the Earth with De la Fitte's illustrations: Penn's Comparative Estimate of the Mineral and Mosaical Geologies: Fairholme's Scriptural Geology: The Mosaical and Mineral Geologies Illustrated and Compared, by W. M. Higgins: Bakewell's Geology, with additions by Prof. Silliman, 2d American Edition: Dr. Macculloch's System of Geology: Ure's Geology: Gleig's History of the Bible: Turner's Sacred History: Chalmers Evidences of Christianity: Dr. Buckland's Reliquiae Diluvianae: Rosenmuller Antiquiss. telluris Historia: Whewell and Bell's Bridgwater Treatises: Knapp's Theology Vol. I.: Bush's Notes on Genesis, with several articles in the London Christian Observer and the Philosophical Magazine.

* Superposition of Rocks, p. 201.

† Geological Manual, p. 433.

For the lower beds pass insensibly into primary rocks: and generally, a chemical agency is obvious in their structure, in the veins of quartz by which they are frequently traversed, and in their semi-crystalline aspect. There is, also, a plumbaginous appearance in the anthracite found in these rocks, which does not exist, except in the carbon of the older intermedial and primary rocks, and which increases with the age of the rock in which it occurs. The Rhode Island coal exhibits more of this character than that of Pennsylvania: and that from Worcester appears much more like mineral carbon than either; which gradation corresponds with the opinion I have adopted as to the relative ages of these several coal formations.

Upon the whole we may be certain, I think, that the formation under consideration in Massachusetts and Rhode Island, is a member of the series generally called transition. But whether it is precisely identical with any European member of that series I suppose we do not yet possess the data for determining. The only organic remains yet found in this formation are vegetable; which will not enable us even to prove that it belongs to the transition series, if a remark of Al. Brongniart be true, that 'no species of plant has been found in the transition series, (*terrains hemilysiens*,) which being peculiar to that class, differs essentially from those found in the later rocks.'* And we have seen that Adolphe Brongniart regards as belonging to the first period of vegetation, all the rocks below the new red sandstone.

After these explanations, I trust it will be obvious that it is not my object to identify the rocks in question, with the graywacke of Europe: but *simply to describe them as they are.* And though it would be gratifying to find that all our fragmentary and fossiliferous rocks correspond exactly with those of other continents, yet I am more and more inclined to doubt whether such identity can ever be made out. For if, as we have every reason to believe, these rocks were deposited in the beds of former seas and lakes, as similar ones are now forming, why should we not expect as much diversity in their composition and organic remains, in different quarters of the globe, as we should find in the sandstones, conglomerates, and limestones, which would result from the consolidation and elevation of the sand, gravel, and calcareous matter that constitutes the bottom of existing seas, estuaries, and lakes? Should such a consolidation and elevation take place, we might perhaps find resemblances enough between distant strata to prove them of contemporaneous origin, and the result of the same general causes. Still, we should undoubtedly find much in each group of strata, of a *sui generis* character, and not a few groups entirely peculiar and independent: though produced during the same geological epoch. Hence, then, is it not best to direct one's chief efforts to give a correct description of our rocks, rather than spend the time in attempts to identify them with European formations? Many writers seem to feel as if nothing were done, until this identity be established. But it may appear hereafter, that their labor has been almost in vain. How much toil and perplexity have geologists endured, in endeavoring to ascertain whether particular formations ought to be referred to the transition class of Werner! and yet, how few geologists there are now, who do not admit that there is scarcely the vestige of a foundation for this class in nature: regarding its introduction into the nomenclature, (in the words of Mr. Greenough*) like an attempt 'to increase the list of primitive colors by the addition of mixed tints, or the list of notes in music by telling in the flats and sharps.'

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* Tableau des Terrains, p. 291.

In the present case, however, waving all general principles such as have been alluded to, I freely confess that I am not thorougly enough acquainted with the formation which I denominate graywacke, to be able to decide whether it does, or does not, correspond with any known European formation. Long and patient study of its organic remains and relative position, with the advantage of a residence in its vicinity, ought to be bestowed upon it, before we can settle this question. On this account I regard it as premature to describe as new, any of its anomalous varieties; although some of them differ so widely from the general type of the group, that they really deserve distinct names, when these can be applied without the danger of encumbering the science with synonymes. If it be the geologist's object to advance the science, he ought to forego the gratification, and it may be the honor, of affixing new names to anomalous rocks, until they have undergone a most rigid scrutiny. Indeed, in my opinion, very few of the rocks in this country, except perhaps the primary ones, have yet been examined thoroughly enough to render it certain that they are so radically different from those already described in Europe, as to deserve distinct names. Whoever covets the ephemeral honor of applying them thus prematurely, may be sure that every cautious and able geologist will refuse to adopt them; and will regard them as more indicative of self-sufficiency and vanity, than of scientific acumen.

Mineralogical Characters of the Graywacke.

This rock varies in texture from the finest argillaceous slate and shale, through all the grades of sandstones, up to the coarsest conglomerate and breccia. The imbedded nodules in the coarser varieties, consist of almost every sort of primary rock found in the eastern part of Massachusetts: and the prevailing cement is argillaceous: sometimes, however, it is a paste of compact feldspar, and at others of mica, talc, or steatite. Perhaps, however, a particular description of the distinct varieties of this group will convey the most accurate idea of its characters. I begin with those which probably are most common, and most forcibly arrest the attention of the most unpractised observer.

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* Greenough's Geology, p. 233.

I. *Conglomerates.* The rounded nodules in the variety that abounds most throughout the whole extent of the formation, (Nos. 287 to 292, and 307,) particularly in Roxbury, Dorchester, Dighton, Swansey, and Somerset, consist of granite, sienite, compact feldspar, and perhaps hornstone of various colors, porphyry, quartz, argillaceous and flinty slate, novaculite, serpentine, and nephrite. These vary in size from that of a pea to two or three feet in diameter. The cement appears to be chiefly the same materials in a comminuted state: exhaling, however, an argillaceous odor when breathed upon. Although the imbedded nodules are numerous, yet they have the appearance, as Mr. Maclure describes the older conglomerates, 'as if the cement at the time of formation had a consistence sufficient to prevent the particles from touching each other.' The cement has generally a semi-crystalline aspect, and adheres very firmly to the nodules. Sometimes the rock is traversed by veins of quartz, which are attached quite strongly to the rock. So thick, and often indistinct, are the strata, that the Messrs. Danas say that 'no stratification has been observed in this Graywacke.'* But if one traverses the whole formation, he will find abundant examples of this structure; and in most places he will discover it by careful examination; the strata having in general a northerly and easterly dip. This rock is also intersected by numerous cross seams, more commonly perpendicular to the layers, and remarkable for the exact division which they make of the imbedded nodules; so that one part of the pebble appears on one side of the seam, and the other part on the opposite side. Veins of trap, also, sometimes traverse this conglomerate; as will be particularly noticed in describing greenstone.

Another very distinct and most remarkable conglomerate occurs at the south east extremity of Rhode Island, in Middletown, near Sechuest Beach, three miles east of Newport. (No. 294.) It is composed of elongated rounded nodules of quartz rock, and quartz rock passing into mica slate, with a cement of talcose slate. The nodules vary from the size of a pigeon's egg, to four, and even six feet in their longest diameter, and constitute the great mass of the rock. They are so arranged that their longest diameters are uniformly parallel to one another: lying in a north and south direction: which corresponds with the layers of the schistose cement, and also with the general direction of the strata in the vicinity. Both the nodules and the cement abound in small, distinct, octahedral crystals of magnetic iron ore.

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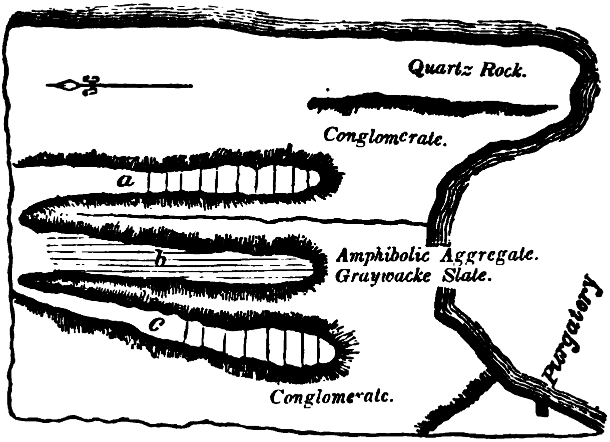
* Mineralogy and Geology of Boston and its vicinity, 1818, p. 94.



The above rough sketch of the southeast point of Rhode Island, will assist in rendering intelligible the relative positon of this conglomerate, and also of three or four other varieties of this formation to be hereafter described. About a quarter of a mile from the coast, three precipitous bluffs, *a*, *b*, *c*, several rods wide, separated by salt marshes from 15 to 20 rods wide, rise one or two hundred feet, trending northerly, and converging; so as apparently to unite at no great distance. The two most easterly ridges are very steep, and exhibit evidence of having been powerfully abraded. The outer ridges, *a*, *c*, consist of the peculiar conglomerate above described; the central one consists of a hard graywacke slate, and a very singular and puzzling rock, which I shall venture to describe as an amphibolic aggregate. (No. 371.) Half a mile southeast is an aggregate of quartz and mica to be described in the sequel.

So much of the topography of these rocks, by way of anticipation, seemed necessary in order to explain the peculiar structure of the conglomerate. The layers of the graywacke slate and amphibolic aggregate run north and south, and dip west, from 60° to 70°. And this, as already mentioned, is the direction in which the nodules and schistose layers of the cement of the conglomerate are placed. But no strata seams are to be seen corresponding to the dip and direction of the slate. Yet the conglomerate is divided into horizontal layers, from six to ten feet thick; and also by fissures running east and west, perpendicular to the horizon, and parallel to one another, from 10 to 20 feet apart. These fissures divide the thick masses of conglomerate so perfectly, that they seem as if cut through by the sword of some Titan. The nodules through which the fissure passes, are divided very neatly, and the parts present even surfaces, so as to give the rock a quite peculiar aspect. At the southern extremity of the eastern ramification of the range of hills above described, an immense quantity of the conglomerate has been carried away by former diluvial action, and the present bluff is terminated by a perpendicular wall, exhibiting this bisection of the nodules in a most striking manner. On account of the size, number, and parallel position of these nodules, this singular instance of fracture is much more remarkable than in the variety of conglomerate first described.

No one can view this phenomenon without inquiring immediately into its cause. And it is obvious at first thought, that this division of the strata must have taken place since their perfect consolidation: otherwise the nodules, instead of breaking, would have been drawn out of the paste. Nor could mere desiccation have produced such an effect, for the same reason. Nor does any hypothesis afford to my mind the least satisfaction, except that which supposes these fractures to have resulted from a powful force, acting at right angles to the meridian, beneath the conglomerate, after its consolidation. And when we find large deposites of granite in the vicinity, we have ascertained the existence of a power adequate to such an effect: although we might resort to the hypothesis of Elie de Beaumont, which has of late excited so much interest, and which imputes most of the fractures and dislocations of the earth's crust to the secular refrigeration of its internal parts, whereby its outward envelope becomes too large and partially plicated.

Another important fact in respect to the conglomerate under consideration, is the occurrence in it of numerous veins of quartz. Some of them are not less than a foot wide; and they are frequently branched. These veins separate the imbedded nodules, and are chemically united to the divided portions. These veins and the semi-crystalline aspect of the cement of this rock, prove it to be one of the oldest of the varieties which I have included under the term graywacke.

2. *Breccias.* These are distinguished from the conglomerates by the angular shape of the imbedded fragments. One variety (Nos. 296, 297,) consists of fragments of reddish and ash colored argillaceous slate, united by an argillaceous or an arenaceous cement. This aggregate is slaty, and the cement has a porphyritic appearance. I have observed it only in a few places; as at Na-

tick and Randolph. Another variety, approaching to slaty porphyry, appears to be composed chiefly of compact feldspar, united by a cement of comminuted porphyry. This was found also in Natick. (No. 298.) A third variety, (No. 299,) of which I found only a bowlder in Saugus, consists of gray compact feldspar (?) and indurated wacke. (?) A fourth consists of fragments of gray and yellowish green compact feldspar, united by an unknown dark colored cement. (No. 300.) The yellowish green variety appears as if colored by epidote. This most singular rock occurs at the head of Nantasket Beach, in Cohasset; and when its ledges are moistened by the spray, they present a most fantastic and really a very splendid appearance, resembling exceedingly variegated serpentine. The rock exhibits no regular strata, although divided like the unstratified rocks generally by numerous seams. It is associated with a conglomerate, similar to the variety first described above, and I suspect it to be the rock marked in Cohasset, on the map of the Messrs. Danas, as 'Petrosilex.' If large blocks can be obtained and it will admit of being polished, it will furnish an elegant ornamental stone.

The conglomerate just mentioned, as associated with the breccia at the head of Nantasket Beach, extends into Hingham; and both in Cohasset and Hingham, it assumes a character intermediate between puddingstone and breccia, by taking into its composition angular and partly rounded masses of porphyry, greenstone, and amygdaloid. These are sometimes so numerous, that the rock might easily be mistaken for a variety of trap. Neither this rock nor the conglomerate, of which, indeed, it forms a part, exhibit, so far as I could perceive, any evidence. of stratification: although being a rock of mechanical origin, it is undoubtedly stratified.

As we pass from the range of porphyry and compact feldspar on the south of Boston towards the graywacke, and if I mistake not at the junction of the two rocks, (e. g. in Dorchester and Canton,) we meet with a rock of a peculiar character, whose origin appears to be in part mechanical. The compact feldspar seems to have suffered some degree of abrasion after its consolidation, and the fragments to have been reconsolidated into a rock more or less slaty, with the admixture of but few foreign ingredients. (No. 301, 302.) It would seem to have been partially fused the second time; or perhaps it might have been produced by the partial cooling of the compact feldspar at its junction with the graywacke, as it was forced through that rock while in a melted state. This would account for its semi-brecciated aspect and slaty structure, and the occasional presence of foreign ingredients. But this rock deserves a more careful examination than I have been able to give it.

Our compact feldspar is slaty in some other places; as at Newbury; but it does not appear to have been recomposed.

3. *Quartz Rock.* I thus denominate two or three singular varieties of rock in the formation under consideration, because quartz is their predominant ingredient.

The most remarkable of these varieties is developed very distinctly at the southern extremity of Rhode Island; as may be seen by the sketch already given of that portion of the Island. It consists of coarse grains of hyaline quartz, of a purple color, passing to deep blue and black, with talc or mica; (it is difficult to say which;) the materials having a schistose arrangement. (Nos. 303 to 306. The quartz bears a strong resemblance to peliom, and constitutes a large part of the rock. The aggregate exhales an argillaceous odor when breathed upon.

This same rock may be seen at the mouth of Fall River, in Troy, where it is associated with an argillaceous slate, passing into mica slate, and of a quite dark color from the carbonaceous matter it contains. At this place, this slate and quartz rock are contiguous to granite; and they may be seen in Tiverton, lying directly upon the granite. In Newport, also, granite cannot be far distant from the same rock. Do not these facts furnish a clue to the origin of the dark color of the quartz? Was it not penetrated by the carbonaceous matter of the black slate, while in a state of partial fusion by the action of the melted granite?

There can be no doubt but the quartzose rock above described, is one of the oldest of the graywacke formation. Its position in respect to the granite is proof of this. In Newport it lies between the very ancient conglomerate that has been described, and the granite; although the granite does not appear, I believe, till we cross an arm of the sea into Little Compton.

Another aggregate, in this formation, which may be called quartz rock, consists of red or reddish hyaline quartz, somewhat in grains, with a small quantity of mica, so that the rock always has more or less of a slaty structure; though this is not always seen but by close examination. (Nos. 309 to 318.) In some instances its layers become quite thin, in consequence of an increase of the mica: but they are still genuine strata; for these layers have a schistose structure, not coincident with their surfaces. This red quartz rock exceedingly resembles red sandstone at a little distance: but when closely examined, it is found to consist chiefly of red hyaline quartz, which exhibits little evidence of a mechanical mode of production. It passes into a structure distinctly conglomerated, and may perhaps be the equivalent of Dr. Macculloch's 'primary red sandstone;' though I have no evidence that it alternates with any primary rock: and it contains no feldspar.

Sometimes this rock abounds with veins of quartz giving it a very rich appearance. I have noticed these veins most numerously in the south part of Wrentham, near the place of explorations for coal. (No. 318.)

4. *Talcose Aggregate*, (*Steachist?* Phillips and Wood) (Nos. 320 to 323.) This is a slaty rock, composed of grains of quartz and sometimes feldspar, with talc or steatite. It lies between the red quartz rock and the primary rocks in Walpole; though not, therefore, older than the quartz rock; since the dip of both is such there, as to bring the talcose rock uppermost. It often exhibits distinct fragments of previous rocks, and passes into a breccia or conglomerate; as in a quarry in Cambridge, two miles west of the University. It is not abundant in the graywacke formation; though many of the oldest varieties of this formation have a talcose appearance.

5. *Classical Graywacke.* I mean by this term to designate the rock described by Werner's ablest commentator, Professor Jameson. He says that Graywacke 'is composed of angular or other shaped portions of quartz, feldspar, Lydian stone, and clay slate, connected together by means of a basis or ground of the nature of clay slate, which is often highly impregnated with silica, thus giving to the mass a considerable degree of hardness. The imbedded portions vary in size, but seldom exceed a few inches in breadth and thickness.' Brochant does not include in the term graywacke, any variety of rock 'whose grains exceed the size of a hazle nut.' Hence the conglomerates that have been described above, cannot be regarded as *classical* graywacke. This is the opinion of Professor Webster;* whose opportunities for a personal examination of European graywacke, give his decision on this point great weight. But associated with these conglomerates, we have rocks of a much finer grain, whose composition corresponds essentially with the above definition; (Nos. 324 to 334,) although every ingredient may not in all cases be present. Sometimes the mass is colored red by the presence of the red oxide of iron; as in Attleborough. But more commonly it is gray, as in Rehoboth. It often becomes fine grained and passes into graywacke slate, as at the quarries in Pawtucket; where it is traversed by numerous veins of quartz mixed with calcareous spar.

6. *Graywacke Slate.* This variety of rock is quite common in this formation. Its colors are either gray or red; and it appears to be composed in a great measure of wacke. Mica, however, sometimes enters into its composition. Its structure is always slaty: but the layers are much more irregular and tortuous than those of argillaceous slate, and its aspect more earthy; though it is no easy matter to draw a line between them. It is traversed frequently by veins of quartz. (Nos. 335 to 346.)

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* Boston Journal of Philosophy and the Arts, Vol. I. p 289.

7. *Argillaceous Slate.* The argillaceous slate in the eastern part of the State is so intimately connected with the varieties of rock above noticed, that it ought in justice to be described as one of the members of the graywacke group; although marked as a distinct deposite on the Map. That this is one of the oldest varieties of this group, I have no doubt; but certainly not older than some that have been mentioned. I am aware that fragments of this slate occur in one of the varieties of conglomerate that have been described; and this not only shows the posterior production of the latter, but renders it doubtful whether both rocks were produced during the same geological epoch. But with the knowledge that I possess of this series of rocks, I fear that an attempt to divide them would only introduce confusion into my account. I would not pretend to a degree of accuracy to which I have not attained.

I have no doubt that this argillaceous slate is the 'transition clay slate' of the Wernerians, which they describe as associated with graywacke. In various places in Rhode Island and Massachusetts, it is highly impregnated with carbonaceous matter, so as to become black; and it usually forms the floor and roof of the beds of anthracite. In general its color is dark gray, passing to blue: sometimes of a chocolate color, and sometimes red. It is rarely fissile enough to be employed for roofing, and frequently its layers are two or three inches thick. The laminæ, or rather strata, are sometimes much curved; as on Rainsford island, in Boston harbor. Not unfrequently it passes into an imperfect novaculite; as in Charlestown, Roxbury, Weymouth, Newbury, and some of the outer islands in Boston harbor. (Nos. 357 to 370.)

8. *Amphibolic Aggregate.* (No. 374.) Nothing is more difficult in many cases, than to determine the nature of the semi-crystalline minerals entering into the composition of some of the intermediary rocks. They seem to have undergone some chemical process, which has not been thorough enough to give them a fully developed character. In the present instance the mass appears decidedly crystalline; yet I am in serious doubt whether amphibole is the dark green mineral in it that exhibits a crystalline structure. Another part of the rock presents an argillaceous aspect and exhales an argillaceous odor when breathed upon. But had I found it among primary rocks, I should have regarded it as by no means an anomaly there: especially after finding in it a vein, four inches wide, of crystallized zoisite. Yet the position of this rock, which has already been pointed out, in describing the conglomerate of the southeast part of Rhode Island, clearly proves it to be a member of what I call the graywacke series: for it is situated between graywacke slate and conglomerate.

9. *Varioloid Wacke.* The rock which I thus designate, has

generally been regarded by those who have described the geology of Boston and its vicinity, as amygdaloid. But it seems to me that there are insuperable objections against the supposition that the nodules in general were introduced by infiltration, or even sublimation; the only modes by which geologists suppose the cavities of amygdaloid were filled. For they consist generally of rounded masses of compact feldspar; a substance which must certainly have been the result of igneous fusion. On the other hand, the rounded form of these nodules, and their non-crystalline structure in general, forbid the arrangement of this rock along with the porphyries. But some writers regard variolites as rather intermediate between porphyry and amygdaloid,* and such I suppose to be the character of the rock under consideration. By the term varioloid, I intend merely to designate the external aspect of the rock; since the mode of its formation seems involved in much obscurity: but its variolous appearance none can deny.

Brochant describes wacke as 'a substance intermediate between basalt and clay.' This description will apply to the base of the varioloid rock under consideration. It is found in Brookline, Newton, Needham, Hingham, Brighton, and Saugus. But its most important varieties are found in the three latter places, and deserve a particular description.

In Brighton, the wacke is of a chocolate color, and quite hard. The nodules are mostly rounded, and of the size of a pea; but sometimes they are much larger and irregular, approaching to the form of veins. Compact feldspar, epidote, calcareous spar, and quartz are the principal minerals of which they are composed. Sometimes the external part of the nodule is compact feldspar, or calcareous spar, and the central part epidote: and sometimes quartz occupies the centre, invested by epidote. The epidote is crystalized, although the cavities are in almost every instance entirely filled. The foliated structure of the feldspar, and especially of the calcareous spar, is not unfrequently visible, though generally these minerals are compact, and very hard. But the two last seem to be strangely blended, as if they had been partially melted together. (Nos. 373, 377.)

At a quarry about a mile southwest of Brighton meeting house, this varioloid rock may be seen passing into conglomerate, showing that it is only a variety of the graywacke formation.

At Hingham, the greater part of this rock is of a deeper red than that at Brighton; though some of it is of a light gray. The basis is harder, owing perhaps to a mixture of compact feldspar. The nodules vary in size from that of a pea to that of an almond; and consist of brownish red and greenish compact feldspar, with carbonate of lime mixed with the latter, or in separate folia. Not unfrequently the red compact feldspar encloses the green, like that in Brighton. This rock is associated with a conglomerate of the graywacke formation. (No. 874.)

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* Traite de Mineralogie, Par. T. S. Beudant, (Paris, 1830,) Vol. I. p. 569.

At the head of Nantasket Beach, I found a rolled mass (No. 375) of the varioloid rock, whose base is brownish gray, and the nodules a greenish compact feldspar.

In Needham, this rock has a somewhat slaty structure, is hard, and contains distinct crystals of feldspar of a light green color. (No. 378.) But as the basis is obviously wacke, exhaling an argillaceous odor, I can hardly persuade myself to place it among the porphyries. Suppose this Needham rock were to be subject to a degree of heat sufficient to fuse the feldspar, without essentially altering the wacke, I inquire whether the result would not be a rock very similar to some varieties that have been described as varioloid wacke. And may not this have been the mode in which some of that rock was produced ?

The most remarkable of the varioloid rocks which I am describing, occurs at Saugus. Near the centre of the place, and surrounded by granite, we find a rock, forming a hill one or two hundred feet high, composed of a basis of green wacke and imbedded nodules of white compact feldspar, with an occasional mixture of carbonate of lime. The nodules are rarely so large as a bullet; more commonly about the size of small peas, and in some parts of the rock so very numerous that it seems hardly possible they could have been infiltrated into cavities previously made. (No. 372.) The basis is a pleasant green. I saw no conglomerate or other variety of graywacke in the vicinity.

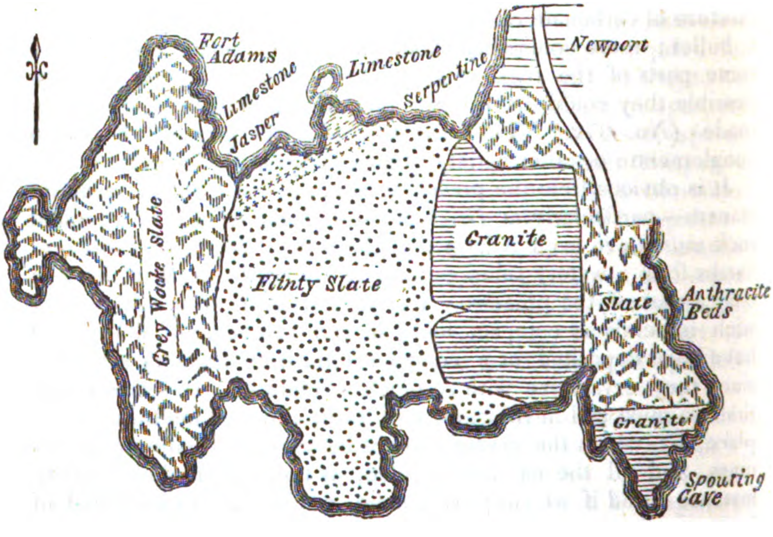
It is obvious from the preceding descriptions, that in some instances—particularly at Brighton—the nodules of this varioloid rock must have been at least partially formed by the infiltration of earths from a watery solution: but it would seem that this was only a part of the process. For it is difficult to conceive how such minerals as compact feldspar and carbonate of lime could have been deposited in a compact form from a watery solution; since they crystallize with so much readiness. It seems to me that we must call in the agency of heat, after the infiltration took place, by which the crystals might be converted into a compact mass, and all the cavities be filled, as they are in almost every instance: and if we suppose granite, sienite, &c. to have had an igneous origin, we can be at no loss to provide for the requisite heat. I had been rather disposed to regard much of this rock as an example of the solid concretionary structure, especially that at Saugus. But the occasional evidence of infiltration led me to abandon that hypothesis. If the one hinted at above is more satisfactory, I shall be gratified. The subject is certainly involved in much obscurity.

10. *Flinty Slate.* 11. *Chert.* 12. *Jasper.* I regard these rocks as varieties of other rocks, altered by the proximity of granite, porphyry, or trap: and in Massachusetts they are merely altered varieties of the graywacke formation that has been here described. Hence I shall treat of them in this place. The sagacious observations of Dr. Macculloch concerning the origin of these rocks,* receive strong confirmation from their situation in New England. And since this is a subject, concerning which geologists are as yet not entirely agreed in opinion, I shall exhibit the relative position of these rocks as intelligibly as possible, from the examinations of them which I have been able to make.

Flinty Slate, or Siliceous Schist.

This rock I have found only in two places in the district which I am describing; viz. in Newport, R. I. and on the promontory of Nahant. It is interesting, however, that in the former place it occurs contiguous to granite, and in the latter, to trap.

It is not this slate alone which in Newport exhibits the influence of the proximity of granite: and it will save space to give an account here of the whole of this interesting spot, to which I was conducted by Col. Joseph G. Totton of the U. S. army, who has become familiar with the geology of that region, and to whose polite attentions I am much indebted.



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* System of Geology, Vol. I. Chapter XL.

The preceding rough sketch of the southwest part of Newport, will give a correct idea of the relative position and extent of the four or five rocks which are there associated, on a surface of four or five square miles; viz. granite, flinty slate, graywacke slate, limestone, serpentine, and jasper. The flinty slate, it will be seen, occupies a considerable space immediately contiguous to the granite, and it is separated from the graywacke slate on its west side, by a small ravine. The flinty slate exhibits various degrees of induration, and more or less of a mixture of different minerals. One variety has a gray color, an imperfectly conchoidal somewhat splintery fracture, and is rendered porphyritic by small grains of hyaline quartz. Another dark gray variety exhibits greenish and white clouds. A third has a reddish base of an earthy aspect and fracture, less hard than the preceding, and contains numerous light colored, rounded masses, resembling hornstone, from the size of a pin's head to that of a musket bullet; giving it an amygdaloidal aspect. If hard enough to receive a polish, it would form an elegant ornamental stone. A third variety exhibits a semi-crystalline aspect, and contains minute scales of mica. This variety is traversed by veins of granite, composed of quartz and flesh-colored feldspar. (Nos. 380 to 383.)

For the most part, this rock exhibits scarcely no marks of stratification. But not unfrequently, even in the most highly indurated masses, the traces of a former slaty structure are distinctly visible. In short, it is quite obvious, that it is the graywacke slate, which has been subject to a heat so powerful as to indurate, and for the most part, to melt it. I think it would be easy to collect specimens exhibiting almost every gradation from graywacke slate to flinty slate.

In the southeastern part of the above sketch, the granite cuts off the graywacke slate at right angles to the general course of the layers: and the slate is indurated only a few feet from the junction. The junction between the granite and the siliceous slate is obvious in several places, particularly at a ledge at the southwest extremity of the granite: and the two rocks are so firmly united as to separate no easier than in any other direction.

The graywacke slate of this spot has generally the shining or glazed appearance of the oldest varieties of argillaceous slate: but in the extensive excavations that have been made in it for the construction of Fort Adams, we see frequent examples of a brecciated or conglomerated structure. It is also traversed by numerous small veins of white quartz, sometimes combined with flesh colored feldspar.

The serpentine is separated from the granite by a strip of flinty slate. At its eastern extremity it seems to lie between the flinty slate and the graywacke slate, and to have a stratified structure.

But it probably extends to the southwest, (as shown on the sketch by the crosses,) so as to cut across the northwestern point of the siliceous slate. A valley passes through the flinty slate in the direction in which the serpentine runs, and at its extremity, serpentine appears in small masses attached to the flinty slate. It probably forms a sort of vein in the slate, though hid by the loose soil, and at its northeastern extremity the graywacke slate lies immediately north of it, as shown on the preceding sketch. I am inclined to believe, however, that the serpentine was originally interstratified with, or formed a bed (if that term conveys any definite meaning,) in graywacke slate; though the extreme degree of contortion in the slate, where the two rocks join, renders it not easy to decide that point. The serpentine is compact, very hard, and of a very dark color. It might easily be mistaken for greenstone.

The limestone forms a small island, a little distance north of the serpentine; also a small point projecting into the harbor, near Fort Adams. It is entirely destitute of stratification, is perfectly compact, and nearly as hard as quartz. Its general color is a grayish white; but it abounds in gray spots, which resemble chert. (No. 495.) Indeed, the whole mass seems to be well advanced in the process of conversion into that substance. This seems to be the case referred to by Dr. Macculloch, when he says; 'an attempt to the production of this rock (chert) is often observed where the process is still incomplete; and it is evinced by the extreme hardness which such limestones exhibit in the vicinity of granite.'* He refers here to the primary limestones, which are intermingled with siliceous and argillaceous matter: and that the limestone at Newport is primary, in the sense in which Dr. Macculloch uses the term, is evident from the fact, that near the serpentine, a portion of it is seen in the form of a bed, between the layers of graywacke slate: and the limestone associated with this rock, is precisely the kind that is apt to contain a considerable proportion of siliceous and argillaceous matter. In ordinary cases, limestone is rendered more crystalline by the proximity of granite: but where a certain proportion of argillaceous and siliceous matter is contained in it, the effect of heat will be to render it more hard and compact.

A portion of the graywacke slate near Fort Adams is converted into jasper. But a more particular description must be deferred till I have finished what I have to say concerning flinty slate and chert. I shall also have occasion to speak again of the striking evidence, which the group of rocks above described in Newport furnishes of the igneous origin of granite.

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* System of Geology, Vol. II. p. 285.

Flinty Slate of Nahant.

The greater part of this promontory is sienite. But enough of the argillaceous slate remains at its southeastern extremity, to show the geologist the influenee of trap veins in passing through it. These are quite numerous, both in the slate and in the sienite; and sometimes the greenstone is intruded laterally between the strata of slate, in the form of beds. Yet the general dip and direction of the slate appear to be but little affected by these veins, although they frequently constitute more than half the rock. For the basset edges of the slate run nearly east and west, and dip northerly; which corresponds with the general direction and dip of the argillaceous slate in that region. Nearly all the slate, however, on this promontory is much indurated; and a considerable proportion of it converted into genuine flinty slate. The slaty structure is rarely lost, except at the junction of the greenstone and slate, where the two rocks are so intimately blended, that it is not easy to fix upon the spot where either of them commences. This corresponds with the opinion of Dr. Macculloch, that nothing but the requisite degree of heat is necessary to convert argillaceous slate into greenstone. (Nos. 383 to 385.)

Chert.

I have already described a conatus for the production of chert from the Newport limestone. But at Nahant the process seems in some cases to be nearly or quite completed. One observes there, that a considerable proportion of the flinty slate contains layers of a light gray substance, somewhat resembling in aspect and fracture, certain varietes of pottery. (No. 386.) On examination we find intermixed with this substance, a compact or even semi-crystalline limestone. In short, we observe every degree of induration and compactness from limestone to chert. There can be little doubt, it seems to me, that this is a genuine case of the conversion of argillaceous limestone into chert. For, says Dr. Macculloch, 'originating in limestone, the transition from that rock into the chert, is often so gradual, that no precise point can be assigned where the term indurated limestone is no longer applicable.' * None of it, however, at this locallity has that chalcedonic aspect which highly indurated chert often exhibits.

Jasper.

The jasper at Newport, to which I have already referred, occurs a few rods south of Fort Adams. Two or three large blocks of graywacke slate lie upon the shore, a considerable part of which has been converted into red jasper, often mixed with a greenish, translucent, siliceous mineral, so as to form an imperfect heliotrope. Before the mouth blowpipe the greenish variety undergoes no change, except a loss of color: but the red variety loses its color, and becomes slightly glazed at the surface. (Nos. 387, 387 1-2.)

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* System of Geology, Vol. II. p. 284.

The manner in which this jasper has been produced, appeared to me quite obvious: indeed, if I mistake not, we see the various steps of the process. The rock contains a considerable quantity of the magnetic oxide of iron; which, according to the latest writers,* consists of one atom protoxide and two atoms of peroxide. Now the effect of heat would be to convert this moiety of the black protoxide into the red peroxide; and the iron would serve also as a flux for the fusion of the slate; and thus genuine jasper would be produced: for according to Mohs, 'jasper, with its various kinds, is formed, if besides the oxide of iron, clay enters into the mixture, &c.' † Those parts of the rock with which the iron did not mingle, would form hornstone or heliotrope; the latter deriving its green color from the slate, which has a greenish aspect. As the vicinity of this locality exhibits so many marks of the former action of powerful heat, can we doubt that in this manner the jasper was produced? and can we doubt but granite was the powerful igneous agent employed?

Saugus has long been known as a locality of fine jasper. It exhibits a blood red, and generally uniform color; though sometimes striped and clouded with white, so as to be very elegant when polished. (Nos. 388 to 390.) I have been surprised, however, to find how easily it may be fused by the common blowpipe, into a white semi-transparent enamel, containing bubbles; and I can have little doubt but it ought to be referred to compact feldspar, which conducts precisely in this manner before the blowpipe. I am inclined, however, to believe that it contains some argillaceous matter; and it must contain the red oxide of iron to give it its color. It occurs a few rods east of the hill of varioloid wacke, which has been already described, as composed of wacke and numerous nodules of compact feldspar and limestone. Now I suspect that the action of granite on this rock, has converted a part of it into this pseudo-jasper. For granite appears in place only a few feet distant from the jasper; though the actual junction is hidden. If this be the true theory, then the composition of the varioloid wacke is the same as that of the jasper; and since compact feldspar predominates in the former, it probably does in the latter. And if I mistake not, very much of the compact feldspar in the vicinity of Boston abounds in argillaceous matter, as well as iron. In Hingham, indeed, it greatly resembles the Saugus jasper, though of not so rich a color.

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* Thomson's Chemistry of Inorganic Bodies, Vol. I. p. 487. Edinburgh, 1831.

† Mohs' Mineralogy, Vol. II. p. 328. Edinburgh, 1825.

13. *Graywacke Limestone.* I have already stated the reasons that induce me to believe the indurated compact limestone of Newport to belong to the graywacke formation: and I have nothing more to add in this connection.

There is one other bed of limestone, which I strongly suspect should be referred to this formation; viz. in the west part of Walpole. When I visited the spot, I had no suspicion that this rock had any connection with the graywacke; especially as I observed sienite within a few rods of it. Nor do my notes furnish any very decisive evidence either way as to this question. The dip of its strata, which is about 45° N. W. is the most important circumstance. For I find that the red quartz rock and talcose aggregate, which have been described as occurring a little west of Walpole meeting house, have nearly the same dip and direction, and are succeeded on the west by sienite. Hence I suspect that the limestone, which lies two or three miles southwest from those rocks, may be connected with them: and especially when I recollect, that in all other cases where I have found limestone connected with sienite, it is very white and destitute of stratification: whereas that at Walpole, as already remarked, is stratified and is of a gray color. Perhaps closer examination would discover organic remains. (No. 494.)

The bed of limestone in Bernardston is associated with argillaceous slate, or quartz rock, and contains encrinites; so that probably its age corresponds with that of graywacke. But as it is entirely disconnected with the graywacke, I shall defer a description of it till I speak of the limestones.

Topography of the Graywacke.

I have anticipated so much of this head, that brevity may now be consulted. It will be seen by the Map that this formation is confined exclusively to the eastern part of Massachusetts and Rhode Island; and that it exists in several detached patches. On the present which is the third edition of the geological Map, I have connected the strip of graywacke passing through Dedham, Walpole and Wrentham, with the broad deposite south of the last named place. Nor should I be surprised, if future observers should discover a connection between the graywacke range in Dedham, Canton, and Randolph, and that in Quincy, Dorchester, &c.; although I failed in finding it. The fact is, this rock in no place rises into any thing like mountain ridges; and for the most part, it occupies extensive plains, or gently undulating ground. Diluvium also, is extremely abundant over almost every part of it; so that it is only occasionally, and often at distant intervals, that graywacke is seen in place. This is particularly the case in the most extensive tract of the graywacke, which embraces the greater part of Rhode Island, with nearly every other island in Narraganset Bay, and a strip of uncertain width on the west shore of that bay, as well as a narrow tract on the east shore in Little Compton; and as it extends northerly into Massachusetts, occupies the surface of nearly twenty towns in Bristol and Plymouth counties. In Swansey and Somerset, the most abundant conglomerate of this formation, (which for the sake of distinction I shall call the Roxbury conglomerate, because in that place its characters are strongly developed,) forms several hills of one or two hundred feet in height, producing striking outliers in the landscape. In Dorchester, Roxbury, Newton, Brookline, and Brighton, the hills of the same rock are of moderate elevation; rarely exceeding 200 feet: yet this is the most hilly part of the graywacke formation in Massachusetts. And its low level and the abundance of transported fragments that overspread it, render it extremely difficult to ascertain its limits.

On the first edition of the Map, I put down a patch of graywacke in Duxbury. But on more mature reflection, I feel satisfied that I have not evidence enough, that the slaty epidotic rock which occurs in that place, belongs to this formation. That it is not the classical graywacke, I am certain: nor do I feel satisfied what are the ingredients that compose it; though I suspect the presence of compact feldspar in considerable quantity. Its dip and direction coinciding with those of the graywacke, I was led to suspect that it might be one of the anomalous varieties of that rock. But I shall place the specimens in the collection among those from the gneiss formation; hoping that some geologists will be able to examine this rock carefully in its native situation. This I had not time to do when I passed through the place. And I think it better that it should not be noticed on the Map, than be referred to any formation with no more evidence of its true nature than I at present possess.

It appears, then, that all of the graywacke formation lying south of the Blue Hills in Massachusetts and Rhode Island, forms but a single tract. The slaty varieties predominate on the west side of this tract; and on some of the islands in Narraganset Bay, this slate appears to be passing into the primary schists, particularly into mica slate. The red quartz rock is most abundant in the south part of Wrentham, near the coal mine, and in that branch of the deposite, which occupies the north part of Randolph. It occurs, also, in the west part of Walpole, as already noticed, and likewise in Abington. And from the bowlders of this rock which I noticed in Scituate, mixed with the granite, I am suspicious that it may be found in place from Abington to the coast, in a northeast direction; though I attempted to trace it in vain.

Around Boston we find another tract of the graywacke, occupying a basin, of which the Blue Hills form a southern boundary; the porphyry hills of Lynn and Malden a northern, and the greenstone ranges of Weston and Waltham, a western boundary. The argillaceous slate connected with the graywacke, is all found along the northern and southern sides of this basin, as may be seen by the Map. The central parts are occupied by conglomerates and graywacke slate.

I have already suggested the probability that Boston harbor was produced by the wearing away of the graywacke formation. That this series of rocks once occupied the harbor, is obvious from the character of the islands, which are evidently the remnants of a once continuous formation. It is true that these islands are for the most part covered with diluvium: but sometimes on their shores, we find rocks in situ; and in such case I have regarded the whole island as composed of the rock which is thus developed. On this principle, the geological character of the principal islands in this harbor may be set down as follows:

Noddle's Castle Thompson's Spectacle Islands Long Island Pedock's Gallop's George's Lovel's Deer Island Apple Great Brewster	Diluvial.
Moon Island	Conglomerate
Hangman's Island	Sienite
Rainsford Islands Middle & Outward Brewster Boston Light Egg Rocks Calf Island Green's Island Governor's Island	Argillaceous Slate

It will be seen that argillaceous slate is the predominant rock on the outermost of these islands. In general it is quite hard, and has so little of a slaty structure, that one might well hesitate to call it argillaceous slate. Frequently it appears to be a coarse variety of novaculite. Argillaceous slate likewise appears on the southern side of the promontory of Hull; although the surface is for the most part diluvial.

There can be little doubt that the peninsula of Boston has a foundation of argillaceous slate. This is, indeed, the only rock that has ever been found there in place. And from the occurrence of argillaceous slate in South Boston, and in Charlestown, with a northerly dip in both places, it would be very surprising if any other rock should be found in Boston; unless it were an intruding mass of trap rock. But this slate on the peninsula is buried deep by clay, gravel, and sand; although, from the quantity of diluvium found there above the tertiary beds, I have been led to color the peninsula as a diluvial deposite.

The only remaining tract of graywacke to be noticed, is one of limited extent, along Parker river in the south part of Newbury, and extending, I believe, into Rowley. It consists of gray red and variegated slates, slaty compact feldspar, with talc, and a conglomerate resembling that in Roxbury. Red compact feldspar lies between this rock and the sienite; and some of the nodules of the conglomerate consist of red compact feldspar. This tract of the graywacke appears to be very interesting, and deserves a more thorough examination.

Direction, Dip, and Thickness of the Strata.

Graywacke is celebrated in other countries for the irregularities of its stratification, and the tortuosities of its slaty varieties. Nor is this rock in New England lacking in these characteristics. The observer will be satisfied, after an extensive examination, that the predominant direction of the strata of this rock is not far from east and west, and the dip northerly, generally approaching to 45 degrees. But he will be surprised to find in the western part of the principal deposit, viz. from Randolph to Providence, and so on to the southern extremity of Rhode Island, that the direction of the strata is nearly north and south, and the dip east. The following table exhibits the dip and direction of this formation in various places, as I find them in my notes.

	Direction.	*Dip.*
Mansfield, . . .	N. W. and S. E.	45° N. E.
Berkley, . .	N. E. and S. W.	N. W. small.
Attleborough, (west part,)	North and South.	East, small.
do. (centre,)	do.	50° West.
Walpole, . . .	N. E. and S. W.	50 to 60° N. W.
Pawtucket, (Graywacke Slate,)	S. 20° West.	70° easterly.
From Providence to Warren, Rhode Island.	N. and South.	45° East.
Seekonk, . . .	do.	10° East.
Portsmouth, R. I. (Slate,)	N. E. and S. W.	S. E. 40 to 90°.
Newport, R. I. near Fort Adams, (Slate,)	N. and South.	5 to 10° easterly.
do. South part, (do.)	E. and West.	Various.
do. Southeast part (do.)	N. and South.	60 to 70° west.
do do. Purple Quartz Rock,	N. and South	80° East.

	Direction.	*Dip.*
West side of Narraganset Bay (Slate,)	N. and South.	10 to 15° East.
Middletown, R. I. Blue Quartz Rock,	N. and South.	E. 80° East.
do. do. Amphibolic Aggregate,	N. and South.	60 to 70° West.
Between Warren and Bristol, Rhode Island,	E. and West.	10 to 20° North.
Tiverton Bridge, R. I. (Slate,)	N. and South.	45° West.
Little Compton, (Slate,)	N. E. and S. W.	
Fall River, (Troy,) Slate and Quartz Rock,	E. and West.	45° North.
Swansey, (Conglomerate,)	East and West.	35 to 40° N.
West Bridgewater, (Slate,)	do.	30° North.
North Bridgwater, . .	do.	Northerly.
Canton, ...	do.	25 to 50° N.
Milton, ...	do. (nearly,)	60 to 70° N.
Newton—north part, .	do.	30° North.
Cambridge, . . .	do.	60 to 70° N.
Watertown, . . .	N. E. and S. W.	90°.
Dorchester, (Conglomerate,)	S. E. and N. W.	15 to 30° N. E.
Roxbury, (do.)	do.	do.
Natick, (Slate,) . .	N. E. and S. W.	45° N. W.
Newbury, (Slate and Conglomerate,)	East and West.	45° N.
Milton, (Argillaceous Slate,)	do.	North, large.
South Boston, do.	do.	50 to 60° N.
Nahant, do.	do.	30 to 40° N.
Hull, do.	do.	60 to 70° N.
Rainsford Islands, do.	N. E. and S. W.	Nearly 90° S. E.
Charlestown, do. (near the Insane Hospital,)	W. a little N.	50° S. E.
do. do. (in a quarry,)	North and South.	10° W.
do.[*] do. (Winter Hill,)	East and West.	15 to 20° N.
do.[*] do. (Near the Powder House,)	E. and W. nearly.	15° N. N. E.

The predominant direction of the strata in this formation may be seen on the annexed Map, (Plate XVI.) which shows the general direction of all the strata in the State. Local exceptions, unless of great extent, cannot of course be shown on a Map of such limited size. These exceptions are so numerous in the preceding table, that one might be disposed to question whether any parallelism in the direction, or uniformity of dip, can be made out. But extensive examination will satisfy any one of the truth of the general statement made above, that the prevailing direction is easterly and westerly, and the dip northerly, with the exception there named in Rhode Island, and of a tract from Rhode Island to Randolph. Whether there is a particular line along which the strata change suddenly in their direction from north and south to east and west, or whether the change is gradual, I have not been able to determine; though inclined to believe it sudden. The central parts of the tract, near where the change must take place, are so covered with diluvium as rarely to exhibit rocks in place. As to the cause of this anomaly, I am disposed to believe that this graywacke belongs to two systems of elevation; the one running nearly east and west, and the other nearly northeast and southwest. In the conclusion of my Report, I shall examine this subject more particularly.

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[*] Professor Webster: See Boston Journal of Philosophy, &c. Vol. I. p. 280, et seq.

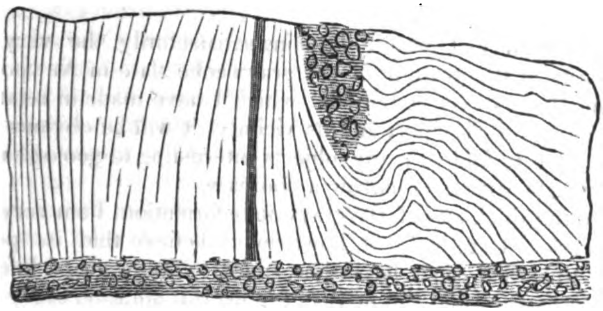
It will be seen from the preceding statement of the direction and dip of the strata, that there is much irregularity in the position of the argillaceous slate connected with the graywacke: particularly in Charlestown. But this in general is easy to be explained by the intrusion of masses of greenstone, or the proximity of sienite.

The slaty structure of the slates included under graywacke, does not always coincide with the stratified structure. I have observed this to be the fact, particularly with a variety of the red quartz rock, which in Randolph, Walpole, Wrentham, &c., becomes slaty, by taking into its composition a larger proportion of talc.

In South Boston, and on Rainsford islands, the argillaceous slate contains a double set of seams, oblique to the strata seams; and thereby the rock is divided, often with great regularity, into tables with rhombic or trapezoidal faces. (Nos. 360, 361.)

In general, I doubt whether the argillaceous slate and the graywacke slate of this formation, exhibit such striking tortuosities in their layers, as European geologists describe in the corresponding rocks in the eastern world. In some places, however, these curvatures are remarkable enough in New England. On Rainsford islands the argillaceous slate, although unusually fissile, is bent so as to form a semicircle within the space of a very few inches. (No. 362.) But in the southern part of Newport, Rhode Island, in the vicinity of granite, we find the most remarkable curvatures in the graywacke slate.

The following sketch was taken from a cliff on the southeast shore of that town. It is from 15 to 20 feet high, and 30 or 40 long, and the drawing does not at all exaggerate the tortuosities and irregularities of the slate. The dark strip is a bed of anthracite a few inches thick; and the dotted part shows where the diluvium has slidden down upon the rock. The slate is so highly impregnated with carbon as to be quite dark colored, and might perhaps be denominated shale. Near the anthracite bed it abounds in vegetable remains. I could discover no strata seams distinct from those that separate the layers of slate; and it is very doubtful whether this rock ought to be regarded as stratified at that place.

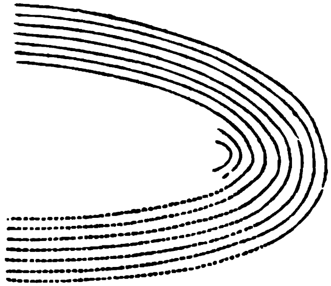


Coast Section in Graywacke Slate: Newport, R. I.

It is obvious that this slate must have been bent into its present form while yet in a plastic state; although its elevation to a nearly perpendicular position, might have been the result of a subsequent convulsion. It will be recollected, that in giving a history of our tertiary strata, I have exhibited some remarkable examples of tortuosity in the clay beds, which bear a strong resemblance to the one figured above; and perhaps both were produced in a similar manner, however difficult it may be to assign any adequate cause. Other similar cases I shall describe when I come to speak of mica slate and gneiss.

In another place on the same coast, near where the preceding sketch was taken, the graywacke slate seems to have assumed the form of a paraboloid, or an ellipsoid, whose longer axis coincides nearly with the plane of the meridian. The upper part of this paraboloid having been worn away, leaves the basset edges of the slate as exhibited below.

The dotted portion in the following sketch, is covered by debris and sand; but very probably the position of the laminæ is as represented. The dip of the slate is outward on every side; or in such a direction as it would be, if the layers curved around a paraboloid, or ellipsoid, from which a segment had been cut off.



The proximity of granite explains satisfactorily the very great irregularity in the position of the graywacke slate in Newport.

From the various statements which I have made in relation to the geology of Newport and its vicinity, it will be obvious that it is very rare to find so many objects interesting to geological curiosity brought within so narrow a compass.

As to the thickness of the graywacke formation, I am very much in the dark. I am inclined, however, to believe that its perpendicular thickness must be rather small. The want of lofty hills in this formation, and the marks of powerful abrasion every where exhibited, both in the loose fragments and in occasional outliers, have impressed me with the idea that it was once far more extensive than at present. It might not, indeed, have covered all the space that now intervenes between its several tracts: but I see no reason why much of that space might not have been occupied by it: although I confess that this opinion is little more than hypothesis.

Mineral Contents.

By far the most interesting and important mineral in the graywacke formation is anthracite. Its most abundant and best known locality is in Portsmouth, near the northern extremity of Rhode Island. It was explored there somewhat extensively near the beginning of the present century; and Dr. Meade says, that the vein then wrought was 14 feet wide; and 'with only fifteen workmen, they can raise at present from 10 to 20 chaldrons of coal per day, besides keeping the mine free from water; from which they suffer little inconvenience.'* He speaks of the bed of coal as 'not horizontal or vertical, but forming an angle of about 75°.'

A great variety of causes led to the abandonment of these explorations: but a few years since they were again resumed; and through the kindness of Dr. Thomas H. Webb, of Providence, I have before me a letter addressed to that gentleman, from J. Clowes, the intelligent agent employed to superintend this second exploration; from which I derive the following facts respecting the anthracite of Portsmouth. The letter is dated February 18th, 1828; which appears to have been about the time when the work was the second time abandoned.

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* Bruce's Mineralogical Journal, January, 1820, p. 84.

The quantity of anthracite raised at these mines in 1827, by 20 men and 5 boys, was 2200 tons, and an equal quantity of *slack*: that is, very small coal and dust. The former sold at the mine for $4.50 per ton, of 2240 pounds; and the slack for $1 per ton. The slack was used for burning lime and bricks. The best coal was mostly employed for fires in families, except in New York, where it was used for making glass; for generating steam under the common circular or round boiler; for blacksmiths; and in general for any purpose where anthracites are employed.

The agent regards these mines as capable of furnishing an inexhaustible supply. He represents the coal as occurring in veins; but his descriptions apply rather to beds; and I am almost certain that it occurs in beds. Six of these have been exposed; and more than 30 are said to exist in that part of Rhode Island. Their direction is southwest and northeast, and they dip southeast from 40° to 90°.

The following are the strata that were penetrated in sinking a *water shaft*, or *engine pit*, 87 feet; and in fifteen other places they were found to be very similar.

Sand and gravel, . . .	9 feet.
Dark colored slate, . .	12
Hard compact graywacke, .	23
Soft black slate, ...	4
Hard brown slate, . .	5
Soft fine gray slate, . .	1
Very hard brown slate, . .	17
Gray freestone, . . .	12
Coal, ...	4

Vegetable remains were found only in one of these excavations, about nineteen feet below the surface.

The failure of the mining operations in Portsmouth, between the years 1809 and 1816, resulted, according to Mr. Clowes, from two general causes: 1. A want of practical skill in those who conducted the operations. This prevented as much system in the works as was necessary, and also the introduction of proper and economical machinery. And he says, that 'amongst the many losses, which contributed to work their ruin, that was not the least, of allowing, or permitting the workmen to have from half a pint to a pint of spirituous liquors during the working hours. We neither allow nor permit any thing of the sort, nor is it allowed or permitted in any mining establishment in Europe. Instead of benefiting a man, it actually incapacitates him: and exclusive of the immoral effects on the passions of the workmen, I consider it a loss to the owners of at least one sixth of the whole manual labor.'

The second cause of failure, he says, lay in sending the coal from the mines in an improper state; that is, unsorted, and in too large lumps. He says that the R. Island coal does not break easily when ignited, like the Lehigh coal, and that this fact and the amount of impurities which it contained, injured its reputation in the market. He thinks that if mixed in equal quantity with the Pennsylvania or bituminous coal, it answers best for fuel: and he says he has abundant evidence, that one ton of the R. Island coal, mixed with a ton of that from Pennsylvania, is equal to two tons of the anthracite from the latter state.

These facts, coming as they do from a practical and intelligent man, I thought deserving of a place in this Report: for they render it probable to my mind, that the Rhode Island coal may be again wrought ere many years. At present the prejudice against it in market is so strong, that the owners have been obliged to abandon its exploration.

I have already mentioned that beds of anthracite, a few inches thick, occur in the south part of Newport in graywacke slate. In the war of the Revolution, the British troops, after consuming nearly all the wood upon the island, endeavored to find coal at this place; and the marks of their exploration still remain.

On the Map I have represented a bed of coal as existing near the east line of Cumberland, another in the north part of Middleborough, a third in West Bridgwater, and a fourth in Wrentham. I could not learn that much of this mineral had been obtained at these places. The search for coal in Weymouth, mentioned in a note to the first part of my Report, first edition, has not I believe been successful.

An exploration is now going on in the south part of Wrentham, principally by boring. In one place they have penetrated 180 feet into a dark colored or anthracitous slate, which runs nearly east and west, and dips north about 45°. But in no place have they found pure coal: nor has any bed, even of that which is impure, been discovered more than eighteen inches thick. The specimens hitherto obtained, (No. 401,) are much mixed with pyrites and slate.

It struck me that boring perpendicularly is not the most judicious method of searching for coal in this place. I take it to be quite certain, that the coal always occurs in layers between the laminæ of slate, and never in veins; such a thing as a genuine vein of coal being, as I suppose, inconsistent with the known laws of chemistry. Hence then, as the strata dip 45° at this place, if a trench be dug deep enough to lay bare the basset edges, crossing them at right angles, it must certainly reveal all the beds of coal which the rock contains. And since the loose soil is not more than ten feet deep, this must be certainly the most economical course. The discovery of beds of coal in other places by boring, leads often, I believe, into error: for generally the strata containing coal are horizontal; and then boring alone will bring the beds to light: but where they are highly inclined, it is working to great disadvantage to bore into them perpendicularly. I have found several times that foreign miners, who are ignorant of the principles of geology, have led our citizens astray by assuring them that the coal or the ore they are in pursuit of, lies deep; merely because such was the case in the particular mine in Europe with which they were acquainted.

In all the cases mentioned above, the anthracite occurs in a slaty rock, either gray or nearly black, which is associated with coarser aggregates. Many geologists would denominate this slate *shale:* but I should rather term it argillaceous slate, or graywacke slate; because I prefer the system of Macculloch, which regards no rocks as shale, which lie as low in the series as graywacke.* (Nos. 358 and 395 to 399.)

In no case have I found anthracite in any of those anomalous varieties of the graywacke group, which I have described; such as the breccias, amphibolic, quartzose, and talcose rocks. These I regard as the oldest varieties of this formation; and the anthracite I suspect occurs among the higher members of the series. I know of no reason, however, why this mineral should not be found in the oldest varieties. That the slate in which it is found in Rhode Island, is closely allied to primary rocks, is obvious from the fact that it abounds in veins of asbestus—and the same mineral penetrates the anthracite.

So full a description of the external characters of the Rhode Island anthracite has been given by Prof. Silliman, in his Journal of Science,† that it seems unnecessary to repeat it in this place. I shall merely notice some peculiar characters, which, if I mistake not, have an important bearing upon the theory of the origin of this mineral and its connection with plumbago. In comparing this coal with the anthracite from Pennsylvania, one is struck with the superior semi-metallic or plumbaginous aspect of the former; as I have already remarked. But mere resemblance to plumbago is not all; for, says Professor Silliman, 'many of its surfaces are covered with a thin film of a substance not to be distinguished from plumbago, as it has the same lustre and softness, and stains the fingers and marks paper in the same manner. A true plumbago is found occasionally among the slates which accompany this anthracite.' But in respect to the Pennsylvania anthracites he says, 'there is rarely on these surfaces a plumbaginous aspect; and when it exists, it is less remarkable than in the Rhode Island coal.' In the Worcester coal, I would also state, that the metallic aspect is much more distinct, and the quantity of the substance 'not to be distinguished from plumbago,' much greater. Indeed, several tons of it have been ground and sold for plumbago;* and I think an examination of No. 775, will satisfy any one that it is genuine plumbago. The anthracite found at Cumberland, Rhode Island, also, 'is more slaty than that of Portsmouth, it soils the fingers more, and approaches graphite.'† The specimens from the recent exploration in Wrentham, bear a resemblance in appearance to the anthracite from Rhode Island.

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* Classification of Rocks, p. 455. Also, System of Geology, Vol. II. p. 248.
† Vol. XI. p. 87.

Now do we not ascertain from the preceding facts, a gradual passage from anthracite to plumbago? And if my view of the relative age of the Pennsylvania, Rhode Island, and Worcester anthracites, as they have been expressed in the first part of my Report, are correct; we see that this gradation corresponds to the relative antiquity of the rock containing the mineral: that is, the older the rock, the nearer does the mineral approach to plumbago. I may not indeed, have shown very conclusively that the graywacke formation of Massachusetts and Rhode Island is older than the anthracite formation of Pennsylvania; though the greater dip of the slate, as a general fact, in the former, its more crystalline aspect, and the occurrence in it of crystallised veins of absetus and quartz, render this opinion probable. But as to the anthracite formation in Worcester, it will be easy to prove, in the proper place, that it is older than either of the others above mentioned: and here it should be recollected we find the greatest quantity of plumbago.

The anthracite from these different localities exhibits, in its specific gravity, a correspondent approach to plumbago. According to Dr. Thomson,‡ the specific gravity of plumbago varies from 1.9 to 2.32: but according to Beudant,|| from 2.08 to 2.45. The first named author says, that he has never met with any anthracite whose specific gravity was as great as 1.5: Beudant, however, says it varies from 1.5 to 1.8. Now according to Mr. Bull, the mean specific gravity of the Pennsylvania anthracite, from five localities, is 1.436.§ He states also the specific gravity of the Rhode Island coal to be, 1.438: But Prof. Silliman, who

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* Robinson's Catalogue of Minerals, p. 78.

† Cleavland's Mineralogy, Vol. I. p. 501.

‡ Inorganic Chemistry, Vol. I. p. 155.

|| Traite de Mineralogie, Vol. II. p. 262.

§ Chemistry of the Arts, p. 33.

appears to have conducted the process with great care, states the Pennsylvania anthracite to have the mean specific gravity 1.55, and that from the Rhode Island, 1.75.* Mr. Bull places the Worcester coal at 2.104. Upon the whole, though there is not a little discrepancy in the above statements, we may, I think, safely infer, that the Rhode Island coal is heavier than that from Pennsylvania: and the Worcester coal the heaviest of all, and nearly equal to plumbago.

There is another fact that deserves to be noticed in this connection. Plumbago, it is well known, contains so much iron, that some chemists regard it as a carburet of iron. Now from the analysis of Mr. Vanuxem, † it appears that the Rhode Island anthracite contains a much larger proportion of the oxides of iron and manganese, than that from Pennsylvania; even more than some specimens of plumbago. Do we not in this circumstance perceive another evidence of an approach to that mineral in this anthracite? I am not aware that the Worcester anthracite has been analysed; nor have I time to attempt its analysis before completing this Report.

European geologists have satisfactorily traced the progress of vegetable matter from the living vegetable matter into peat, and thence to bituminous coal. They have, also, rendered it probable that anthracite is only another step in the process; although some of them still doubt the vegetable origin of this variety of coal. But in regard to plumbago, a somewhat prevalent opinion I believe is, that it has been produced from elementary, rather than organized carbon. Dr. Macculloch, however, says, that 'the coal of secondary origin, containing vegetable remains is converted into plumbago by the influence of trap; as wood has been in my experiments, and as coal is, daily, in the iron furnaces: so that even the plumbago of the primary strata, no less than the anthracite, might as well have originated in vegetables, as that each of them should owe an independent origin to elementary mineral carbon.' ‡

Elie de Beaumont has also given an account of anthracite, which is associated in the Alps with graphite in clay slate, reposing on lias. 'This graphite,' says he, 'is found in a bed of argillaceous slate which contains vegetable impressions, similar to those which accompany other deposites of anthracite in that country. This slate exhibits on the surface of these impressions minute veins of anthracite, and it forms a part of a series, in which, both above and below, workable anthracite shows itself: all which proves that the graphite is only a modification of the anthracite. This modification appears to be connected with the presence of certain feldspathic rocks, which are probably only the ramifications of a huge mass of feldspar situated near.'* If I mistake not, the circumstances under which these varieties of carbon occur in this country, throw some light on these inquiries, and render probable the suggestions of Dr. Macculloch. The great number of vegetable remains found in connection with the Pennsylvania and Rhode Island anthracites, must, it seems to me, satisfy every reasonable man of the vegetable origin of this mineral in these instances. But a plumbaginous substance occurs with the Rhode Island coal, and the coal itself seems to be passing into plumbago. Still more near to plumbago do we find the Worcester anthracite, and a part of the bed is undoubtedly real plumbago. Here, however, we find no vegetable remains, retaining their organised form, because the rock belongs to the primary class; being for the most part a bastard kind of mica slate. Advancing one step farther, we find in the gneiss rock of Sturbridge—probably the oldest of all rocks—a bed of well characterised plumbago. How very probable that all these varieties of carbon have the same, and that a vegetable origin? How unphilosophical, when we can thus trace nearly every step of the change, from one variety into another, to call in the aid of other causes to account for the origin of one of them? We see here only the operation of the cause, or causes—whatever they were—by which, as we descend from the newer to the older rocks, they exhibit less and less of a mechanical, and more and more of a chemical arrangement of parts, and fewer and fewer traces of organic remains: until, in the primary rocks, these relics are nearly or quite obliterated. Why should we doubt the operation of such causes upon coal, any more than upon other mineral masses? And if we do grant this, we have an easy and satisfactory explanation of the mode in which all the varieties of carbon were produced, except perhaps the diamond: and from the fact that the diamond breccia of India is surrounded by, and based upon granite, we may reasonably conjecture that this mineral has been produced from vegetable carbonaceous matter, that has been fused, (for Prof. Silliman has proved that it is fusible) and subsequently crystallised † And if it be true, that secondary coal is sometimes converted into anthracite and plumbago by the influence of trap, why should we doubt but heat has been the agent of those changes in every case; especially as it is difficult to conceive how any other agent could have given to rocks and minerals of a mechanical origin, a crystalline or sub-crystalline structure.

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* Journal of Science, Vol. XI. p. 89 and 92.

† American Journal of Science, Vol. X. p. 102.

‡ System of Geology, Vol. I. p. 297.

It will be perceived that I have anticipated some statements in respect to the Worcester anthracite and the Sturbridge plumbago.

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* Annals des Sciences Naturelles, Tome. XV. (1828.) p. 377.

† Edinburgh Journal of Science, Vol. X. p. 184.

This I have done that I might treat of their origin together, to avoid repetition.

I have said so much in the first part of my Report, in respect to the economical uses of the anthracite of our graywacke formation, that I need add nothing here. I cannot, however, but express my surprise, that the ablest European geological and chemical writers should still represent anthracite as of little or no use, except for furnaces; when, for the last ten or fifteen years, so many thousand tons of this mineral have been used in our principal cities, along the whole Atlantic coast, in the parlor, the study, and the kitchen; and so much has been said of its value, for these purposes, in our scientific and other periodical journals. 'In an economical light,' says Dr. Macculloch, 'it must be fruitless to search for coal below the old red sandstone, and generally speaking, beneath the mountain limestone; as to mine after primary coal (anthracite as I understand him,) would be a wild project.' * 'Anthracite,' says Beudant, 'on account of the difficulty with which it is kindled, cannot be employed but in furnaces with a good draught.' † 'The difficulty which is experienced in the combustion of anthracite,' says Dumas, 'is a very great obstacle to every economical use of that body.—It is possible, indeed, that anthracite will one day become useful in deep furnaces; although in almost every other process of the useful arts, its employment can be hardly practicable, on account of the high temperature which it requires to complete its combustion.' ‡

The other minerals that have been found in the graywacke of Massachusetts and Rhode Island, are few and unimportant. It is hardly necessary to mention such common and widely disseminated minerals as iron pyrites, crystalline quartz, and calcareous spar. Magnetic iron ore and the micaceous oxide, have also been found in this group in small quantities; and I have already mentioned crystallized epidote, in the varioloid wacke. In the amphibolic aggregate, in Newport, I found a vein of crystallised zoisite, about four inches wide, and several feet long. In other parts of the globe, graywacke is a repository of gold; and the clay slate connected with it, (transition clay slate,) contains the richest veins of silver in New Spain, according to Baron Humboldt.|| But neither of these metals have been found in these rocks in Massachusetts.

In the varioloid rocks of Brighton, Professor Webster has found sulphate of lime and baryta. The latter is said to occur also in Milton: and also fibrous limestone in thin veins in wacke. Adularia and sulphuret of copper have been found also at Brighton.

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* System of Geology, Vol. II. p. 305. London, 1831.
† Traite De Mineralogie, Vol. I. p. 717. Paris, 1830.
‡ Traite De Chimie Appliquee aux Arts, Vol. I. p. 606. Paris, 1828.
|| Superposition of Rocks, p. 105.

Efflorescent and massive sulphate of iron has been found, according to the Messrs. Danas, on the argillaceous slate in Charlestown.

Dr. Robinson says that the graywacke, near Providence, is traversed by veins of quartz, containing fluor spar.

In Brighton, in the varioloid wacke, I noticed fibres of green asbestus traversing quartz, which, by the coloring matter of the asbestus, was converted into prase. (No. 391.)

Organic Remains.

Having been disappointed in several efforts to obtain organic relics in the graywacke formation, where I knew them to exist, I am prepared to give only a meagre account of them in this place.

All those which I have met with, were probably of vegetable origin.

In Taunton I was shown several imperfect specimens obtained near the village, which evidently belong to some of the gigantic races of plants now extinct, which flourished in the earlier periods of the world. I recognised them as bearing a strong resemblance to some of the larger species occurring in the coal mines in the valley of Wyoming in Pennsylvania: but having had no opportunity to compare these specimens with drawings, or descriptions, I can describe them only in general terms.

In Attleborough, east parish, a mile south of the meeting house, I found an organic relic in a dark hard slate, which so much resembles the Fucoides found in the new red sandstone of the Connecticut valley, that I cannot but refer it to that genus; not, however, without doubts as to its nature. (No. 400.)

According to Dr. Webb,* vegetable impressions are found on slate in Pawtuxet, which lies on the west shore of Narraganset Bay, south of Providence. They seem to belong chiefly to the fern tribes.

The same is true, I believe, of those found at the coal mines in Portsmouth. It was probably from this locality that the two specimens mentioned in De la Beche's Manual† were obtained. One is the fern *Pecopteris arguta*; and the other, the anomalous plant, *Asterophyllites equisetiformis*; which as yet has been referred to no established class.

In the southeast part of Newport, where occur some narrow beds of anthracite, vegetable remains are common. Of two of these I have given a sketch. Plate XI. fig. 10, bears considerable resemblance to an Equisetum, as figured by Adolphe Brongniart on plate 12, fig. 13, of his Vegetaux Fossiles. Plate XIII. fig. 43 may be a delicate species of Nevropteris of the same author. I noticed there some other species of the same genus.

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* Am. Journal Science, vol. VIII. p. 225.

† Pages 416 and 419, second edition.

In the collection of the Academy of Natural Sciences in Philadelphia, is a specimen from Newport, R. I. which, without doubt, must be regarded as a *Sigillaria;* that is, the trunk of an arborescent fern: presenting cicatrices similar to those upon the gigantic tree-ferns now growing in tropical regions.

Vegetable impressions have been found in considerable quantity in the excavations for coal in Wrentham. The most common is what I have supposed to be several species of Calamites, of Ad. Brongniart. Some of them are several inches in width; and are marked out on the rock by a plaited layer of green indurated talc—a most remarkable mineralizer! Plate XIII. fig. 41, represents a small portion of one of those Calamites, which exhibits numerous small seams running obliquely across the specimen, like the C. nodosus of Brongniart. On fig. 42 may be seen two quite different impressions: *a* and *b* are furrowed longitudinally, and appear to be branched: perhaps a part of an Equisetum. The other fan-like impression, with radiated striæ, may perhaps belong to the genus Cyclopteris of Ad. Brongniart: though I am not without suspicion that this also may be an Equisetum.

Theoretical Considerations.

In general the theoretical views that have been presented in relation to the origin of the new red sandstone, will apply to the graywacke. Two or three circumstances only, in relation to this latter rock, need any additional remarks.

One is the more decided evidence, which the graywacke presents, of the operation of chemical agencies in its production. This is obvious in the more crystalline aspect of the rock in general, and especially of certain varieties; and in the numerous veins traversing it, which must have resulted from a play of chemical affinities. And if it be admitted that internal heat in the earth, which every thing proves must once have been very powerful, has been gradually operating less and less upon the crust of the globe, why is it not a natural inference, that the older the rock the more crystalline would be its structure: that is, if we admit that the heat has been great enough to change the arrangement of the particles of rocks, whose origin was mechanical: and it appears that such a change may take place, to some extent at least, far below a melting heat. Only admit then, that the graywacke is an older rock than the new red sandstone, (and it seems to me that the veins in the former are sufficient to prove this,) and we should expect in it a more chemical structure.

Another peculiarity in the graywacke, so far as we are acquainted with its organic remains, is, that all of them are of vegetable origin. Whether all of them grew upon dry land is not so certain; if, as I have suggested, a Fucoides occur in this rock.

The beds of anthracite, however, prove that this rock was formed, in part at least, on a surface elevated above the waters. Yet we must call in the aid of powerful currents to account for the accumulation of rounded nodules, which are so abundant and so large in some varieties of this rock: and then the inclined position of the strata proves that they have been elevated since their deposition. Indeed, it seems difficult to explain all the phenomena in this graywacke, or any other formation containing coal, with some marine relics, without supposing at least one or two elevations above, and depressions below the waters, during the period of its deposition. And if we admit that various portions of the earth's crust have from time to time been elevated, it is easy to conceive that other portions must have been depressed.

The occurrence of the remains of arborescent ferns in this rock, demonstrates the existence of a tropical climate in Massachusetts previous to its deposition: a conclusion to which we have already been brought in regard to the period in which the materials of the new red sandstone were produced. These facts harmonize with those which have been brought to light in other regions of the globe; and there seems no longer any reason to doubt, that the temperature of the globe in early times must have been far higher than at present. The region around Boston, and consequently the whole of New England, was undoubtedly once covered with dense tropical forests.

6. ARGILLACEOUS SLATE.

This is one of those rocks whose mineral character is clear; it being composed of schistose clay, more or less indurated. This character, however, applies to the shale of the secondary rocks, which few geologists now include under argillaceous slate. It also applies to some of the slaty varieties of graywacke: and Dr. Macculloch includes under argillaceous slate the whole of the graywacke formation, as well as that argillaceous slate which is associated with rocks older than graywacke. But De la Beche limits the term to this last named slate, excluding the graywacke, which he puts into a separate group. I prefer his arrangement upon the whole; though in adopting it I find myself perplexed to determine whether the argillaceous slate around Boston, belongs to his 'Inferior stratified or Non-fossiliferous Rocks,' or is a member of the graywacke group; where, for the sake of convenience, I have described it. I am inclined to believe that it should be separated from the graywacke; though with my present information, I cannot say exactly where the dividing line should run. But the fact that no organic remains have been hitherto discovered in this slate, and the occurrence of its rolled nodules in some of the conglomerates of the graywacke, as well as its geological position, render it probable that it is considerably older than most varieties of graywacke.

In respect to the other patches of argillaceous slate exhibited on the Map, there can be little doubt but they belong to De la Beche's Inferior Stratified or Non-fossiliferous Rocks; though I doubt not but some of them would be placed by a Wernerian geologist among the 'transition clay slates.' But I regard it as quite unprofitable to enter upon the long agitated question whether our clay slate belong to the transition or primary class of rocks. It will be in season to discuss this point, when any one can show where the transition class begins or ends; and when there shall be even a tolerable agreement as to the place in the series where the primary class commences. A mere inspection of the tabular view of our rocks, which I have given in the Atlas, will show that our views on these points will depend upon the system or classification which we adopt. I shall feel satisfied if I can correctly describe the position of this rock in respect to others. In what follows, I shall leave out of the account the argillaceous slate in the vicinity of Boston.

Mineralogical Characters.

The common argillaceous slate, which, in its most perfect state, forms roof slate, is the only variety of importance belonging to this formation. This passes by slow gradations into mica slate; so that it is often impossible to say where the one terminates and the other commences. Hence some of the specimens which I place under mica slate, other observers would place under argillaceous slate, and *vice versa.*

The laminæ in the best varieties are straight and even: but as it approximates to mica slate, they become minutely undulated, the surface resembling exceedingly that of certain shales of the new red sandstone already described. Some of these intermediate varieties are remarkably contorted: but these I shall describe under mica slate.

In Guilford, Vt. through which the Franklin county range of this slate extends, I have observed that it passes into a fine grained variety of chlorite slate, and even perhaps into novaculite. That range also abounds with tuberculous masses of white quartz. Veins of quartz also occur in it, as I shall have occasion to show more particularly; and in Guilford we find protruding masses of a porphyroid granite, passing into compact feldspar, and a slaty mixture of this last mineral and quartz. The Worcester county range, also, contains granite.

Topography of the Argillaceous Slate.

With the exception of that in the vicinity of Boston, the Map exhibits but three ranges of argillaceous slate: viz. in the counties of Worcester, Franklin, and Berkshire. And it happens that in all these cases, except perhaps the first, the principal part of the range lies out of the State, either in New Hampshire, Vermont, or New York. Two miles south of the centre of Halifax, Plymouth county, also, I found a delicate variety of argillaceous slate, which I was informed was discovered in digging wells, and that it lay immediately upon granite. (No. 363.) But whether it exists to any considerable extent in that region, I am unable to say.

Worcester county Argillaceous Slate.

Some geologists would probably regard the slate that forms the roof and floor of the mine of anthracite in Worcester, as argillaceous slate; and maintain that the range of this slate in Worcester county, extends at least as far south as that spot. But I regard that slate rather as a fine mica slate, much impregnated with carbon, which gives it the appearance of argillaceous slate. In almost every case the scales of mica are quite distinct: and at a short distance from the mine, the rock assumes the characters of mica slate distinctly; though here, as in most of the range of mica slate extending from the mouth of Merrimack river to the State of Connecticut, much of the rock is so quartzose that it might perhaps be regarded as quartz rock. I have not found any well characterised argillaceous slate, south of Boylston. And north of this place, the country is so much covered with diluvium, and so little hilly, that the slate does not often come into view. I found the range, however, to become narrower on approaching the north line of the State. Its characters appear most fully developed in Lancaster, where it has been quarried for roofing slate; and here the range is broadest. How far it extends into New Hampshire I have not ascertained; though I should not be surprised to find it even crossing that State. In passing from Groton to Townsend, I saw frequent examples of protruding masses and veins of granite in this slate. It passes on either side into the peculiar mica slate, already spoken of in Worcester county; and in this latter rock protrusions of granite are not unfrequent.

Franklin county Argillaceous Slate.

It will be seen by the Map that this range occupies a considerable part of the town of Bernardston, passing into quartz rock on the east, and into mica slate on the west, and embracing a considerable part of two mountains of considerable height. It is not, however, till we pass into Vermont, that this slate assumes its most perfect characters. In Bernardston it is quarried, indeed: but not I believe for roofing slate. But in Guilford, which adjoins Massachusetts, several quarries are opened for this purpose. It there forms hills of considerable elevation; and such is its character farther north. It has been traced northward, in the valley of the Connecticut, 80 or 90 miles, in Vermont; nor do I know that its northern limit has yet been ascertained.

Berkshire county Argillaceous Slate.

This ought perhaps rather to be called the argillaceous slate of Renssalaer and Columbia counties; for the principal part of it lies in New York, in the eastern part of these counties. Near the western line of Massachusetts it passes into mica slate, talco-argillaceous slate, and chlorite slate, by taking mica, talc, and chlorite, more or less abundantly, into its composition. The same rock forms hills and patches of limited extent in Williamstown, New Ashford, Richmond, West Stockbridge, Egremont, and Sheffield. But in no place in Massachusetts will it answer for roofing slate. For this purpose it is wrought extensively in Hoosic, Lebanon, and Hinsdale, N. Y. I doubt very much whether the whole of this stratum in Massachusetts should not be regarded as an imperfect kind of mica slate, similar to an intermediate rock of doubtful character occurring in Hawley, Plainfield, &c., which I have ranked with mica slate. Still, as Professor Dewey, who has examined this rock more than I have, regards it as argillaceous slate, I follow his judgment.

On the west, this range is connected with the graywacke formation of Renssalaer and Columbia counties; and on the east, it is associated with mica slate, and a limestone usually regarded as primitive.

Dip, Direction, and Thickness of the Strata.

Excepting in the argillaceous slate connected with the graywacke, I have not been able to find in this rock planes of stratification running in a different direction from the laminæ; a circumstance very common, it is said, in Europe. But in general, strata seams are discoverable, lying parallel to the slaty structure, as in mica slate. The slate, indeed, contains numereus seams not coincident with those of the strata: but there is rarely any continuous parallelism among them.

The predominant direction of the strata and of the laminæ of slate in all the ranges of this rock, except that around Boston, and that in Franklin county, is north and south, and the dip large; as the following extract from my travelling notes will show.

In Worcester county.

Harvard and Lancaster; direction, north a few degrees east; dip, 90°.

Shirley; direction, north and south; dip, west, small.

Pepperell and Townsend: direction, north and south; dip, 30° to 60° east.

In Franklin county.

Bernardston; direction, north and south; dip, 20° to 90° east.

Guilford, Vt.; direction, between north and northeast; dip near 90°.

In Berkshire county.

Taconic range: direction, north and south; dip, 15° to 70° east

If, as I have supposed, the strata seams are parallel to the laminæ of the slate, and the dip approaches 90 degrees, then the actual thickness of this rock will not be much less than its breadth on the surface. As to its perpendicular thickness, I know nothing.

Organic Remains.

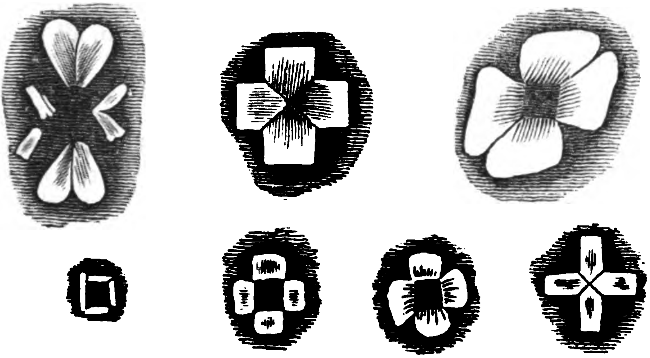
No vegetable or animal relic in a fossil state has hitherto been found in the argillaceous slate of Massachusetts. Since, however, this rock in the eastern part of the State, is associated with graywacke, and in the western part of the State, passes into the same, it will not be strange if organic remains should hereafter be found in it. Every range of this rock, however, in the State, we have reason to believe, belongs to the oldest varieties of argillaceous slate, which geologists have described.

Mineral Contents.

The slate of the Taconic range sometimes contains octahedral crystals of magnetic oxide of iron, as well as the sulphuret of the same metal.

The clay slate in Charlestown, is frequently traversed by veins of crystallized quartz and calcareous spar.

The most interesting mineral in this rock is the chiastolite, or macle; which is found in Sterling and Lancaster. There is a great variety in the manner in which the prisms are disposed. The following are end views, of the natural size, of some of the most interesting forms.



This mineral is quite abundant in the clay slate in these towns, near the place where the rock passes into mica slate. It changes insensibly into the mineral which has been generally called andalusite; and the opinion of some of the ablest mineralogists of the present day,* that macle and andalusite are the same species, derives support from this locality. I have found this mineral in small crystals in a loose mass of argillaceous slate in the town of Worcester. (No. 404.)

In the dark colored slate that lies immediately contiguous to the anthracite bed in Worcester, I have recently found beautiful specimens of green amianthus, (No. 1549) and good specimens, also, of bucholzite; (No. 1550) or if it be not bucholzite, I am greatly mistaken. This latter mineral is now generally regarded as a variety of fibrolite. The Worcester specimens, however, differ considerably in appearance from the fibrolite of Lancaster, but very much resemble the bucholzite found in the State of Delaware. I have also been led to regard the rock embracing the Worcester anthracite as a variety of mica slate: yet it would generally be called argillaceous slate; and perhaps it ought to be. At any rate, I have recently received, through the kindness of Mr. Lucius F. Clarke, specimens of genuine argillaceous slate, from Castleton, Vt. containing very well characterised bucholzite, associated with very singular ovoid nodules of compact sulphuret of iron.

Evidence of Disturbances in the Argillaceous Slate.

I do not here refer to those agencies by which the layers of this rock have been elevated from a horizontal to a nearly vertical position; nor to those by which its usual flexures have been produced; but to some movements that have taken place in certain anomalous directions. The instances which I shall refer to, all occur in the Franklin county range, and mostly in Guilford, Vt.

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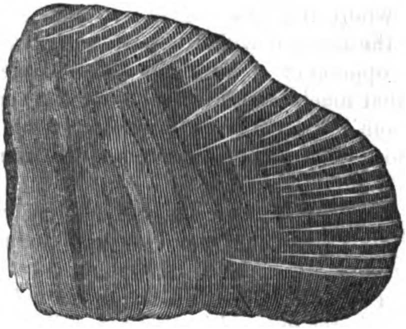
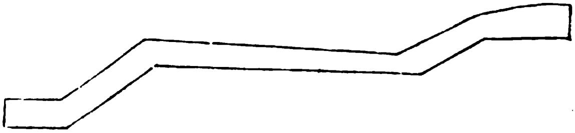
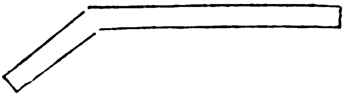
* Beudant's Traite de Mineralogie, Vol. II. p. 45. An interesting paper on the identity of macle and andalusite, with numerous drawings of crystals from Lancaster, by Dr. C. T. Jackson, is contained in the first No. of the Boston Journal of Natural History, just published. (June, 1834.) He has clearly ascertained that the two minerals are only varieties of one species.

In some instances we find veins of quartz in the slate, as represented below. Here it is obvious, both from the curvatures in the undulating ridges of the slate, and from the wedge-form shape of the veins, that a force must have acted latterally on the edges of the laminæ, while they were in a partially plastic state: and that an infiltration of quartz must have taken place subsequently. It is not perhaps difficult to conceive how such a lateral action might have taken place, when the strata were originally elevated. The specimen from which the drawing was taken, (No. 411.) was found near the north line of Guilford, on the stage road.



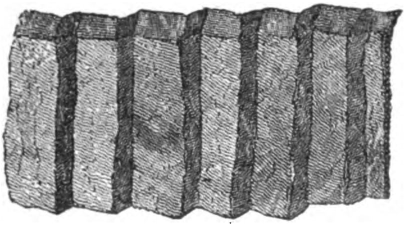
In the principal quarry of slate in that town, on the stage road to Brattleborough from Greenfield, are seen occasionally divisions, perpendicular to the horizon, and to the laminæ of the slate, which are nearly vertical, and run north and south. Not unfrequently, however, the slate at these cross fissures, when its edges are viewed from above, is bent as in the following figures, which exactly represent the specimens, No. 417 and 418.



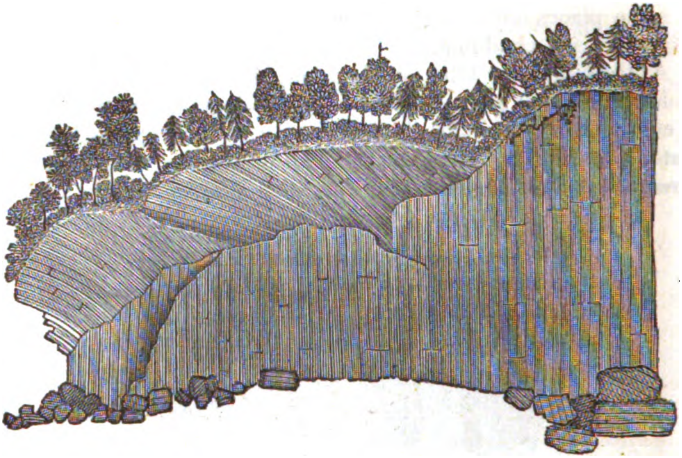


In the latter case the flexure is so great that the slate is partially broken; and this is the case frequently; showing that when the disturbance took place, the rock was only imperfectly plastic. The quarry where these flexures are exhibited, has been so much excavated, as to leave a wall 20 or 30 feet high; and excepting at these transverse fissures, the laminæ are remarkably even; so that the phenomenon is rendered very striking. It must obviously have resulted from the unequal action of some disturbing force—perhaps that by which the strata were elevated—whereby one portion of the rock was pressed forward, faster than the rest; though in some places not enough to separate, but only to bend, the slate while in a soft condition.

At the Gorge, or Glen, in Leyden, I found a series of such slides on a small scale, exhibited by the slate: as in the following sketch; though perhaps the rock ought to be regarded as mica slate. (No. 416.) Here the echellon movement took place in a direction at right angles to that described above.



Another disturbance, much more remarkable, appears at the quarry in Guilford above referred to. In the following sketch the observer faces the north, and looks directly upon the edges of slate, as it remains at the north end of the quarry, in its natural position. The almost uniform dip of the strata, in every part of this quarry, is nearly 90°; leaning, however, a little to the east. And such is their position at the north end of the quarry, to the height of 15 feet, as represented in the sketch. But from 10 to 15 feet of the upper part of the slate are bent towards the west, so as to incline to the horizon at almost every angle, from 0 to 90°. Where the flexure commences, the laminæ of the slate are quite broken off, and not simply bent, as in the case of the disturbance in a perpendicular direction above described. Hence I infer that the former flexure was not produced so soon as the latter; not indeed until the rock had become perfectly consolidated. The quarry lies upon the western slope of a hill of slate, one or two hundred feet high; and the facts now related seem incapable of explanation, but by supposing a prodigious blow to have been given to the top of the hill, directed from east to west obliquely downwards. But what natural agent could have exerted such a force on such a point, I confess myself utterly at a loss to imagine. Among the endless variety of geological hypotheses that have been proposed, I could not call one to mind, which would apply at all to this phenomenon, unless it be the supposition formerly advanced, that the last deluge might have been produced by the impinging of a comet against the earth! I confess I could not but inquire whether this might not have been the point of contact!



Disturbance in the Argillaceous Slate: Guilford, Vt.

Theoretical Considerations.

When we consider the nature of the materials composing argillaceous slate, it seems difficult to assign any other origin to this rock, than deposition from water. Indeed, one has only to look at a clay bed, such as occurs in some of the tertiary strata, which we are sure must have been deposited from water, to be satisfied that he has before him clay slate in its unfinished state; since nothing but the consolidation of the clay bed is wanting to convert it into perfect clay slate. But what agency could have affected this consolidation? Mere desiccation would do much; but it is difficult to believe that this could have produced so great a degree of hardness, and that shining semi-crystalline aspect which the older clay slates exhibit. Now we find the laminæ of the clay beds horizontal, or nearly so, and those of the slate highly inclined; and we trace evidences of a powerful force producing flexures in this rock while in a plastic state. Why not then admit that the agency, by which the strata were elevated and the plastic slate produced, was igneous? And then we can easily conceive how the rock should subsequently have been so thoroughly indurated. Especially why hesitate, when the fused matter protruded at the time of the elevation of the strata, meets us in almost every district of much extent, in the form of trap, porphyry, sienite, or granite?

7. LIMESTONE.

No rock is more widely diffused in nature, or less liable to be mistaken, than the carbonate of lime. From alluvial marl to the saccharine limestones associated with gneiss and mica slate, we find an almost endless variety of this rock; but in nearly every case a drop of acid will enable a skillful observer to detect it and distinguish it from its associates. A more formidable difficulty has always met the geologist in assigning to the varieties of this rock their true places in the scale of strata.

Most of the limestone in Massachusetts belongs unquestionably to the oldest varieties of that rock. The newest varieties are the fetid and bituminous, which are associated with the new red sandstone, and which have been already described. I have also given an account of the white compact limestone of Newport, Rhode Island, and the gray limestone of Walpole, with the suggestion that they probably belong to the graywacke series. All the other varieties in the State, I shall describe in this place. And as the localities are rather numerous, and the diversities of composition, structure, and aspect, somewhat great; I shall, to save repetition, follow a topographical arrangement in the description.

Encrinal Limestone of Bernardston.

Since the first edition of the first part of my Report was published, I have had the satisfaction of discovering organic remains, of the family of encrinites, in the bed of limestone in Bernardston. From the highly crystalline character of most of this rock, I had been led to suppose it older than the encrinal or transition limestone; and that it formed a bed in the argillaceous slate of Bernardston, which appears to be one of the oldest varieties of that rock. But its organic remains settle the question of its position; and differing in dip and direction from the slate, I have been led to doubt whether it really forms a bed in that rock. The slate in the vicinity runs nearly north and south, and the dip is nearly 90°; but the limestone runs N. E. and S. W., and dips S. E. not more than 20°. Besides, the rock that is found above the bed of limestone, (No. 601) appears to be mostly composed of quartz, and probably ought to be called quartz rock. It does not lie in immediate contact with the limestone, nor is the slate visible immediately beneath the limestone. Upon the whole, I am of opinion that this limestone lies beneath the oldest variety of the new red sandstone series, which has been described, and upon the argillaceous slate, in an unconformable position. Probably further research might settle this point satisfactorily.

Two species of iron ore occur in this limestone; the magnetic oxide, (*Aimant,* Beudant,) and the bog ore, or hydrate of iron, (*Limonite ocreuse,* Beudant.) The latter is disseminated through a large proportion of the upper layers of the limestone, and also forms masses, several inches thick, between these layers. It exactly resembles the common bog ore, so abundant in our alluvial formations. (No. 504.) This is not the only instance in which I have found this ore between the strata of other rocks, as I shall have occasion to show hereafter; and Beudant mentions several localities in Europe, where the *limonite* is found 'between the beds of divers rocks.'

The magnetic oxide occurs as a bed in the limestone, lower down than the bog ore. The bed follows the dip of the limestone, and that rock is much impregnated with the ore in the vicinity; so as sometimes to produce a sort of brecciated marble. (No. 472.)

It is very obvious that both these species of iron ore must have been of contemporaneous production with the limestone, since it is impossible to conceive how parrallel interstices could have existed between strata so little inclined, long enough to be filled by watery infiltration, or igneous sublimation, or galvanic agency,—the only modes by which metallic repositories have been supposed to be filled. That the bog ore was deposited, as we find the same ore now forming, seems highly probable. But I am not aware of any theory which will satisfactorily explain how the magnetic oxide, which consists of 69 parts of peroxide and 31 of protoxide, could have been produced in conjunction with the limestone.

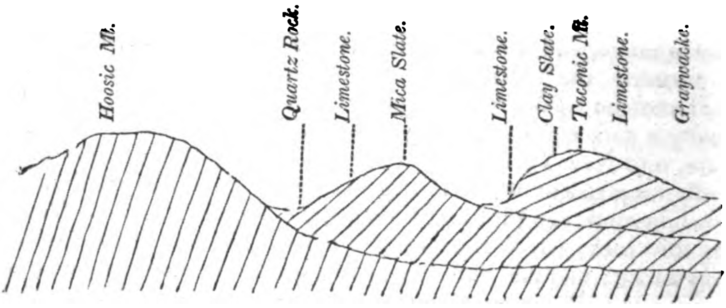
The encrinal remains in the Bernardston limestone are usually quite imperfect; but the transverse septa and the central perforation are generally distinct. Plate XIV. fig. 47, exhibits an end view of one encrinus, about an inch in diameter; and a view of another, lying horizontally in the rock.

Berkshire Limestone.

This rock constitutes a portion of that extensive calcareous formation, which occupies the western part of Connecticut, Massachusetts, and Vermont. It is one of the most extensive ranges of limestone in the world, if we regard it as primary, according to the general opinion of writers. That a part of it is primitive, in the Wernerian acceptation of the term, there can be no doubt:

for it is interstratified with gneiss and mica slate in the eastern part of the range, and it is highly crystalline in its texture. But as we go westerly, the interstratified mica slate passes into clay slate, and the limestone becomes less crystalline, and assumes a gray, and finally a dark color. Passing still farther west, across the clay slate, into New York, we soon come to a range of limestone decidedly more recent, which Professor Dewey has denominated transition limestone, and Professor Eaton, metalliferous limestone. Crossing this rock, which is only a few miles wide, we reach decided graywacke; and this, with some interruptions of limestone, continues nearly to Hudson river; as may be seen on the Geological Map by Prof. Dewey, in the 8th vol. of the American Journal of Science, and on the Geological Section of Prof. Eaton, in his 'Canal Rocks.'

From this statement the geologist infers at once, that here is a gradual passage from the oldest limestone to that which is associated with graywacke. But a singular anomaly in the superposition of the series of rocks above described, presents a great difficulty in this case. The strata of these rocks almost uniformly dip to the east: that is, the newer rocks seem to crop out beneath the older ones; so that the saccharine limestone, associated with gneiss in the eastern part of the range, seems to occupy the uppermost place in the series. Now as superposition is of more value in determining the relative ages of rocks than their mineral characters, must we not not conclude that the rocks, as we go westerly from Hoosic mountain, do in fact belong to older groups? The petrifactions which some of them contain, and their decidedly fragmentary character, will not allow such a supposition to be indulged for a moment. It is impossible for a geologist to mistake the evidence, which he sees at almost every step, that he is passing from older to newer formations, just as soon as he begins to cross the valley of Berkshire towards the west. We are driven then to the alternative of supposing, either that there must be a deception in the apparent outcrop of the newer rocks from beneath the older, or that the whole series of strata has been actually thrown over, so as to bring the newest rocks to the bottom. The latter supposition is so improbable that I cannot at present admit it. But perhaps we may explain the anomaly by supposing a deception in the case. It may be that the relative position of the strata is as in the subjoined ideal section.



Gneiss and mica Slate.

In the greater part of the Hoosic range, the strata of gneiss and mica slate are nearly perpendicular in their dip. As we descend that mountain into the valley of Berkshire, we strike first a range of quartz rock, whose stratification is very obscure, and which moreover is much hidden by diluvium; so that the junction between this rock and the mica slate and gneiss of the Hoosic range, is rarely if ever exhibited. As we proceed west, we find successive and sometimes interlaminated strata of limestone, and mica slate; whose connection with the Hoosic range is no where presented, as nearly all the larger streams of water and the vallies run in the direction of the strata. Now may not the strata of Berkshire valley rest unconformably on the mica slate and gneiss of the Hoosic range? Certain it is that the dip of the former, although in the same direction, is considerably less than that of the latter. It may be, also, that another series of strata farther west, (ex. gr. the clay slate, transition limestone and graywacke,) rest unconformably on the edges of the rocks in the valley of Berkshire, which may pass under this series, as the older mica slate, perhaps, does under the quartz rock and limestone, as exhibited on the sketch: or perhaps the rocks of Berkshire valley lie in a basin, whose eastern side is the Hoosic range, and whose western side is the Taconic range. Then perhaps the transition limestone, clay slate, and graywacke, may fill a second basin farther west. Another series, perhaps, was deposited in a third basin still farther west; and so on till all the earlier rocks are included.

This view of the case is rendered more probable from the fact which may be learnt by examining the sections appended to this Report, (Plates XVII. and XVIII.) that the prevailing dip of the rocks in Massachusetts is towards the east. Why then, it may be asked, is there any more difficulty in regarding the rocks of Berkshire valley as resting unconformably on the the older strata, than there is in respect to the new red sandstone of the Connecticut valley, which has an easterly dip, like the subjacent rocks?

The very great difference of mineral character, between the newer and the older rocks of the latter valley, is one reason why we do not hesitate at all to regard the newer as unconformable to the older: whereas in Berkshire, all the rocks appear to belong to the oldest class; that is, they are highly crystalline and destitute of organic remains. And then the difference of inclination between the varieties of the rocks in Berkshire valley, is much less than in the valley of the Connecticut. Nevertheless, he must be a poor geologist, who does not know that there is often far greater difference in position and mineral character between many members of the primitive class, than between some members of that class and others of the transition, or even of the secondary class. So that the apparently primitive character of the rocks of Berkshire valley, is but a feeble objection against their resting unconformably on those of Hoosic mountain.

The greatest difficulty which I find in the way of admitting the hypothesis above suggested, lies in the fact, that the change from the older to the newer rocks, as one proceeds westerly across Berkshire county, seems to be gradual: whereas, on this hpyothesis, we should suppose, that since the rocks dip to the east, the oldest members of a series ought to be found on the western margin of the several supposed basins; and that the change ought to be sudden and great in passing into the basin next west. But so different does the limestone of the western part of Berkshire appear from that in the eastern part, that Mr. Eaton proposes to give the two varieties distinct names, founded entirely on their mineral characters, that in the eastern part being decidedly the oldest. I think, however, that in considering this question, we ought to leave out of the account every bed of limestone occurring in the gneiss and mica slate of the Hoosic range; since this is unquestionably the oldest of the saccharine limestone. And perhaps the remaining portions of this rock may be found to belong to a single deposit. At any rate, I regard it as premature to assign a distinct name to any part of this limestone range, until one part can be proved to have a different position, in relation to other rocks, from the other. For after what Dr. Macculloch has written on this subject, in his Geology of the Western Islands, and in his System of Geology, it seems to me evident that mineral characters alone can rarely determine even the class to which limestone belongs.

Notwithstanding the difficulties which I have suggested to the hypothesis under consideration, I know of no better explanation of this anomalous case. I am sustained in this opinion by that of Dr. Emmons, of Williams College, whose acuteness of observation and accuracy of discrimination in the various departments of natural history, are well known. It is to be hoped that either he, or Prof. Dewey, whose local situations and geological experience give them great facilities for examining the point, will ascertain the true state of the case, and thus solve an interesting geological problem. Since my attention has been called to it, I have not felt justified by my commission in devoting the time and expense requisite to its solution: since the examinations would delay this Report another year.

The Berkshire limestone passes through numerous gradations of texture and color, from the snow white, coarsely granular, and crystalline variety in Adams, to the white almost sandy dolomite of Sheffield, and to the dark gray almost compact variety in Williamstown, and to the variety even darker of West Stockbridge. The specimens that have been polished (Nos. 428 to 442) will show the principal varieties of marble thence derived. The clouded varieties, although very rich, are less esteemed as marbles, I believe, than the snow white, on account of their liability to be shaky. This tendency results from the nature of these varieties; composed as they seem generally to be, of limestone and argillaceous slate. The different varieties are frequently interstratified at the same quarry.

A large proportion of the Berkshire limestone, especially along its western borders, is the magnesian. In Williamstown this occurs crystallized, or as a rhomb spar: in Bennington, Adams, Lee, Pittsfield, Stockbridge, Great Barrington, New Marlborough, Sheffield, and indeed in nearly every town in the county, it occurs either coarsely granular, and of a crystalline structure, or so finely granular as to be pulverulent. This latter variety, which is genuine dolomite, abounds most in the south part of the county, especially in Sheffield, where, according to Professor Dewey, it is sometimes fetid. In Canaan in Connecticut, which lies contiguous to Sheffield, this dolomite, which is of a snowy whiteness, disintegrates abundantly; leaving in many places loose crystals of white augite and tremolite, which have fallen out. In other places, as in Stockbridge, it is of a gray color.

This appears to be the oldest variety of magnesian carbonate of lime that has been found; corresponding to that described by Beudant, as occurring in St. Gothard, interstratified with mica slate.*

A considerable proportion of the limestone in West Stockbridge, Lanesborough, and New Ashford, is flexible and elastic. Slabs of it a few feet long, and from one to two inches thick, show these properties very distinctly by supporting the ends, especially if they are thoroughly wet. Generally the grain of this variety is coarse and the structure rather loose; though sometimes it is fine grained. Usually it is white, slightly tinged with red; but sometimes gray and dark colored. According to Prof. Dewey, it is the common, and not a magnesian carbonate. The slab in the collection (No. 501) is from New Ashford; where it is abundant. Its peculiar properties seem to depend upon the agency of water: and there are numerous facts that render it probable, that many of the rocks in the interior of the earth are rendered soft and flexible by this same agent: so that although marble and sandstone that will retain their flexibility after being quarried, are rare, yet probably deep in the earth's crust they are abundant.

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* Mineralogie, Tome I. p. 592.

The non-magnesian as well as the magnesian carbonate of lime in this county, is often fetid. In Stockbridge, this is sometimes the case with that which is white and coarsely granular: in Williamstown, this variety is dark colored and fine grained, and in Bennington it is nearly black.

The origin of the fetid odor in limestone, quartz, &c., has been variously explained. The natural explanation imputes it to animal matter, which has been imprisoned since the original formation of the rock; and which is liberated in a gaseous form by friction or a blow. The odor is commonly said to be that of sulphuretted hydrogen: though I confess I do not perceive much resemblance. But even if this be the case, putrescent animal matter would furnish this gas abundantly. And if we adopt the opinion maintained by some very able geologists, that all, or nearly all limestones were produced from living beings, we can easily understand whence this animal matter proceeded.

In general the strata of the Berkshire limestone have a dip towards the east, between 15° and 30°. In some instances it is greater; and Prof. Dewey, from whose account of the Geology of Berkshire, in the American Journal of Science, I have derived much assistance, says, that at the base of Saddle mountain, on the northwest side, some of the limestone dips to the west, and some is perpendicular, although the prevailing dip is to the east. He has given also, in the same work, a drawing and description of a singular conformation of the limestone strata near the College in Williamstown.* Not improbably this is only an example of a concretionary structure on a large scale; though possibly it might have resulted from mechanical agencies in early times.

I have never seen either a mass of granite or of trap, or any other unstratified rock, in contact with this limestone; though not improbably such junction may be found. The following is a sketch of the shifting of a vein of white carbonate of lime, in a slab of light gray marble, five feet long and three feet wide, taken

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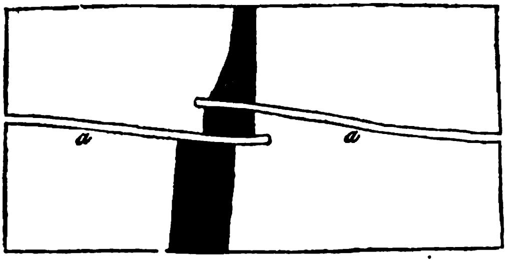
* Vol. IX. p. 19.



from a quarry in New Ashford. *a*, *a*, Is the vein of the carbonate of lime, and *d*, *d*, a somewhat wedge shaped mass of dark gray limestone, five inches wide at its base, which is twice cut off, once by each separate portion of the vein. At present there is no fissures at all in the slab, and apparently it would not break more easily in one direction than in another. As to the strip of darker limestone, *d*, *d*, there is no more difficulty in accounting for its presence, than for any other case of close union between different varieties of a rock. But if we suppose the two veins, *a*, *a*, to have been once united endwise, it is extremely difficult to imagine how they could have been so slidden as to be brought into their present condition. Dr. Macculloch has described a similar case of disturbance in a slab of marble from Ireland in the Transactions of the Geological Society.* But in that case it was not difficult to imagine how the fragments of the vein, by a series of slides, might have been displaced in the manner exhibited upon his drawing. In the present case, however, I despair of being able to explain that sort of double *echellon* movement, by which both the vein and the dark mass of limestone have been displaced.

I am not aware that in any case the limestone of Berkshire county forms hills of any considerable altitude. In general mica slate, with quartz rock, composes those peaks and ridges so striking and sometimes so lofty, in the great valley of this county. Whether the low level of the basset edges of the limestone results from the greater liability of this rock to be worn away, or from its geological position, I am not prepared to say; though inclined to refer it to the latter cause.

In general the limestone under consideration retains its characters distinctly to the very line of junction with other rocks. But not unfrequently the two rocks are intermixed near the place of contact. The dark gray limestones, as already remarked, appear to contain a mixture of argillaceous slate. Frequently we find scales of mica disseminated in the limestones, and thin layers of talc. Where the limestone comes in contact with mica slate, in Canaan, Ct., we find a mixture in almost equal proportions, of carbonate of lime, mica, and quartz. (No. 456.)

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* Vol. IV. p. 393.

In Stockbridge and the south part of Lee, two or three varieties of limestone occur of rather a peculiar character. The most abundant of these has externally a dark gray color, occasioned by one or two foreign minerals, which do not decompose so rapidly as the carbonate of lime. When the specimens are broken, the fresh surface is yellowish. What the disseminated minerals are, I have not ascertained. From the general aspect of this rock where it has been weathered, one would not suspect it to be limestone; and it scarcely exhibits any traces of stratification. (No. 454.) Farther east, at the village of South Lee, this rock is succeeded by white dolomite, whose strata dip west about 45°. A mile farther to the east, they are perpendicular.

A little east of the village in Stockbridge, I found specimens which contained quartz and mica, and which appeared to be limestone passing into mica slate, just as in Canaan, Ct. (No. 458.) The same rock I found in the east part of Lanesborough. (No. 457.)

In passing from West Stockbridge to Chatham, N. Y. we find the gray limestone traversed by innumerable veins of white quartz, so that the mass becomes a real breccia. (No. 453.) This rock is quite abundant near the line of the State. As we pass westerly from this line, the limestone becomes of a darker color and rather more compact, and alternates with bastard mica slate and argillaceous slate. Frequently this limstone is traversed by numerous veins of white calcareous spar, giving it a striking appearance. (No. 452.) It is probably interstratified with graywacke slate in Renssalaer and Columbia counties, N. Y.

I have already mentioned the crystallised tremolites and white augite found in the dolomite of Canaan. The same minerals occur in the same variety of rock at Muddy Brook in Great Barrington, and in New Marlborough, and the former in the south part of Lee and in Sheffield. In the 14th vol. of the American Journal of Science, I have described four modifications of the secondary forms of the augite; and Prof. Dewey, in the 8th vol. of the same Journal, mentions a fifth. In Great Barrington, the tremolite is found in beautiful bladed crystals. This mineral is often delicately fibrous, and sometimes radiated. Indeed, all the varieties are found at these localities. In Sheffield the fibres are sometimes more than two feet long, and embrace crystals of iron pyrites. These fibrous masses are mistaken for petrified wood; to which, indeed, they bear a striking resemblance.

Carbonate of lime is often found crystallised in this rock in tabular, lenticular, &c., crystals. It is also more frequently found laminated. The agaric mineral, it is said, is found in a cave in West Stockbridge. Concreted carbonate of lime occurs in the different caverns that have been described in the second part of this Report. Some of the springs in Williamstown deposit calcareous tufa.

According to Cleaveland's Mineralogy, yellow tourmaline has been found in Dalton, near the Housatonic, in granular limestone.

Blanford Limestone.

After the publication of the first edition of the first part of my Report, Mr. Simeon Shurtleff of Blanford, discovered a bed of serpentine in the northwest part of that town, and in the vicinity, a bed of limestone. The former rock will be described in another connection. The latter will be noticed here. Since their discovery, I have had opportunity to examine them personally : but for the specimens in the collection, I am indebted to Mr. Shurtleff.

The bed of serpentine is about four miles northwest of Blanford meeting house, on the northeast side of a pond. Immediately on the west it is succeeded by hornblende slate, which is only a few rods wide, and then succeeds granitic gneiss. The limestone is about one mile south of the serpentine, and about the same distance as the serpentine, east of the granitic gneiss; and although no hornblende slate appears between them, at the surface, probably it exists there. Indeed, no rock except diluvium is seen in place around the limestone. It shows itself at the surface only over a space whose diameter is about a rod. Its stratification is indistinct; though there is an appearance of parallel division, corresponding to a plane which runs east and west, and dips south about 45°.

The limestone is coarsely granular, white, and crystalline; though it is mixed with a foreign mineral, perhaps augite, in considerable quantity ; and this may prevent its being profitably reduced to quicklime. It is well worth the trial, however, in a region where no limestone is found. (Nos. 477, 478.)

No. 476 was broken from a coarsely granular limestone bowlder near the meeting house in Blanford. It contains numerous plates of graphite disseminated through the mass, and much resembles specimens that I have seen from the shores of lake Champlain : nor should I think strange, if it should appear that this bowlder was brought from thence by the diluvial current, which, as I have shown in another place, once swept over the western part of the State from the northwest.

Limestone in Belchertown.

My attention has been drawn to a bed of limestone in Belchertown, just in season to mark it upon the third edition of the Map, and to notice it in this edition of my Report. It occurs on the farm of Justus Forward, Esq., half a mile east of the meeting house. The specimen which was brought to me, and which I anallised, yielded only 25 per centum of carbonate of lime. Its solution in nitric acid, also was milky, indicating the presence of magnesia. But having visited the bed since, I find much purer specimens. The bed occurs in gneiss, which there dips at a small angle to the northeast. The soil has so covered the limestone that the extent of the bed cannot be determined, until this is removed. The bowlders on the surface, however, indicate its extent to be considerable: and so valuable would be a good limestone quarry in that place, that I think some expense ought to be incurred by digging and blasting, to ascertain the nature and extent of this limestone.

Micaceous Limestone.

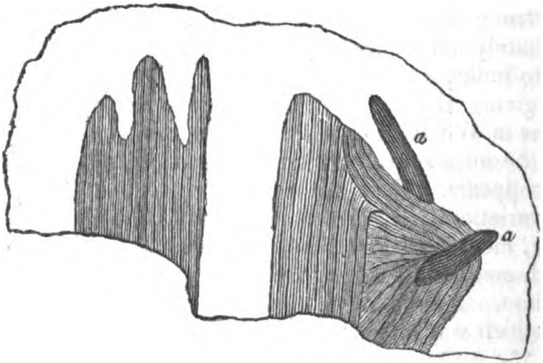
This rock might very properly be regarded as a variety of mica slate: for usually it contains both mica and quartz, the latter always; and much of it is merely mica slate which takes carbonate of lime into its composition. When the carbonate is in small proportion, the schistose structure of the mica slate remains; but when the mica nearly disappears, the slaty structure also vanishes, though still the rock is stratified; the dip and direction conforming to those of the mica slate. It forms numerous beds in the extensive tract of mica slate on the western slope of the valley of the Connecticut; especially along the eastern border of the mica slate, from Whately northwards. Several beds are marked on the Map, merely to indicate that they are numerous, but without any intention of giving them their true situation and extent. In some places, as in Whately, these beds occupy half the surface; but in general the mica slate greatly predominates, and for miles the limestone disappears. (Nos. 459 to 467.)

The varieties of this limestone from Conway, Southampton and Whately, mentioned in the first part of this Report as having been anallised, contain respectively 58, 67, and 78 per cent. of carbonate of lime. Another specimen from Williamsburg, from a bowlder to which was attached a mass of mica slate, yielded 63 per cent. of the carbonate of lime. It also contained magnesia, since its solution in nitric acid was milky. It is, however, doubtful whether this specimen, (Nos. 468, 469,) ought to be connected with the micaceous limestone under consideration.

The carbonate of lime in this rock is very liable to be separated from the mica and silex by the action of air and moisture, so as to leave the surface of the rock coated over with a gray porous mass, sometimes even several inches thick. (No 467.)

This rock is frequently traversed by veins of granite. (No. 465.)

The tortuosities of some of these veins is remarkable; of which examples will be given when I come to describe granite. I have not generally observed any very striking effects produced upon the limestone by its proximity to granite. In one case, however, if I mistake not, a large quantity of argentine has been produced by the action of the granite on the limestone. In a very wild and unfrequented spot in the northeast part of Westhampton, (not in the south part of Williamsburg, as all the authorities state,) a huge mass of coarse granite lies in a valley, apparently in situ. At its southern extremity, which is represented on the following sketch, and which is an uneven perpendicular wall from 10 to 15 feet high, project the edges of schistose rocks; most of which is mica slate, but a part is micaceous limestone. These rocks appear to be merely the fragments which adhered to the granite, when it was raised through the slates, or when these were torn off from the granite. Most of the layers are perpendicular: but some of them towards the eastern side, are much bent and become almost horizontal. Here the argentine, *a*, *a*, appears, lying for the most part between the slate and the granite; penetrating both rocks, indeed, a short distance, but not forming what ought to be called a vein in either. It does not enter the granite, as far as I could ascertain, but a few inches. And it is that part of the stratified rock that lies in the vicinity of the argentine, which is micaceous limestone.



Argentine with Mica Slate and Granite: Westhampton.

Now my hypothesis is, that when the granite was protruded into the mica slate and coarse limestone, while in a melted state, its heat by decomposition or sublimation, or both, forced the carbonate of lime into the cavities that were produced by the elevation of the rocks, where it assumed the form of that very pure variety of carbonate of lime called *argentine* or *slate spar*. Whether its intrusion among the sinuosities of mica slate caused it for the most part to assume a similar structure, I do not undertake to decide. Nor do I feel much confidence in any part of this hypothesis, though it seems to me worthy of consideration.

In Vermont, near Connecticut river, limestone is found among the layers of argillaceous slate. Here it is destitute of mica, and is mixed with the argillaceous slate in such proportion as scarcely to be distinguished from it, except by its effervescence with acids: yet it appears to be closely allied to micaceous limestone.

Limestone of Whitingham, Vt.

This bed of limestene, as may be seen by the Map, approaches nearly or quite to the north line of Massachusetts, and lies near the junction of a range of talcose slate and gneiss. It is stratified and the dip is not far from 30° west, the direction being north and south. By following down a small tributary of Deerfield river, which has laid bare this limestone in the southwest part of Whitingham, a good opportunity is afforded for examining its characters. It is white and decidedly crystalline, though often containing bronze colored mica, and sulphuret of molybdenum in small plates. I found associated with it, also, actynolite, common augite, and mussite. Though a mile or two in length, the breadth of the bed is very inconsiderable. Its geological associations render it certain that this is one of the oldest varieties of limestone.

About 16 miles north of this bed, at an iron or gold mine in Somerset, is a very elegant variety of dolomite, occurring in beds in talcose slate. Some of it exceedingly resembles the purest loaf sugar. (Nos. 483, 484.)

Limestone in Bolton, Boxborough, Littleton, Acton, Carlisle, and Chelmsford.

The geological situation of these limestone masses and their mineral character are so similar, that one description will embrace them all. They all correspond to the description which Dr. Macculloch gives of the limestone of Tirey, one of the Western Islands of Scotland. 'It is,' says he, 'improperly called a bed, as it is only an irregular rock lying among the gneiss without stratification or continuity. In this respect it resembles the greater number of primary limestones found in gneiss and mica slate, and may be considered as a large nodule.'* It will be seen by the Map that all these masses are in a gneiss, formation which, however, often passes into mica slate, and contains numerous protrusions and veins of granite. The dip and direction of the gneiss surrounding the limestone are visible at nearly all the quarries: but the limestone itself rarely exhibits any distinct marks of stratification. And as every one of these localites contains a quarry, a good oppotunity is presented for examining the structure of the rocks.

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* Western Island Vol. I. p. 48.

In my own opinion, there can be little doubt that this want of stratification results from the agency of granite. At any rate, if this be admitted to be a rock of igneous origin, its contiguity to a bed of limestone, while yet in a melted condition, will explain the obliteration in that bed of the stratified structure: and I can imagine no other cause that will explain it. I did not observe, indeed, the contact of granite with the limestone, except at the principal, or north quarry in Bolton. But at that place the stratified structure is more completely destroyed than at any other. Yet I did not search for granite in the vicinity of the other masses of limestone, as my attention was not till recently particularly called to this subject; and probably it may be found near most of them, if not concealed by the soil. Or if not, there is evidence that gneiss has been subject to a degree of heat little inferior to a melting heat.

Nearly all the limestone at these quarries is coarsely granular and highly crystalline. It is almost uniformly fetid also; sometimes so much so as to produce nausea when struck, in a stomach of much sensibility. This was very unexpected to me in limestone of such great relative age; the fetid limestones of Europe being almost exclusively found in secondary rocks.

Although but a single bed of limestone is marked upon the Map in each of the towns mentioned above, yet in most of them there are several; some of them one or two miles distant from one another. In Bolton are two, in Boxborough one, in Littleton three, in Acton one, in Carlisle two or three, and in Chelmsford two or three. Not improbably others exist in the neighboring towns, which escaped my notice.

The simple minerals imbedded in this limestone are numerous and interesting. In general, specimens from the different localities cannot be distinguished; though particular minerals are more perfectly developed at one place than at others; and one or two, perhaps, are found only at one quarry. The most common and abundant mineral is scapolite. It occurs both crystalised and compact; and at all the localities above referred to. The crystallised variety is most abundant at Bolton, Boxborough, Chelmsford, and Littleton; particularly at the two first named places. The crystals are sometimes transparent, more commonly opaque and white, having begun to decompose. Sometimes the crystal exhibits the the primary form, or a right square prism, acuminated by four planes set on the lateral planes. More commonly, however, the lateral edges are slightly truncated. Some of these crystals are one or even two inches in diameter; though in such cases generally imperfect. Often this mineral is compact, and the color either white or lilac red. This red color, however, occurs also in that which exhibits an aggregation of prisms. Bolton and Boxborough yield an abundance of this beautiful variety.

It is probable that the mineral from Bolton, described by Mr. Brooke, under the name of Nuttallite, is only a variety of scapolite.

Augite, actynolite, pargasite, and radiated, fibrous, and brown hornblende, are among the minerals found in this limestone; the two first at all the localities, the third at Carlisle and Boxborough; and the fourth, according to Mr. Nuttall, at Bolton.

Phosphate of lime, sometimes in hexaedral crystals, but more commonly massive, is found at Bolton, Boxborough, and Littleton; usually in scapolite. Its colors are green and purple.

Genuine petalite, (from which lithia has been obtained,) exists at the south quarry at Bolton, associated with the scapolite.

At Chelmsford small masses of black serpentine occur in the limestone, and at Littleton also of a lively green color.

At Carlisle, close by the turnpike from Concord to Groton, Prof. Webster discovered a few years since, a splendid garnet, which is probably a cinnamon stone. The specimens which can now be obtained, give but a poor idea of the richness of some of those which were first procured. Probably extensive exploration might bring to light finer specimens. The same mineral is found at Boxborough.

At Bolton rhomb spar occurs: and both there and at Boxborough, a beautiful variety of flesh colored calcareous spar in foliated masses.

At Bolton, also, a new mineral has been discovered, which Dr. Thomson has denominated from its chemical composition, *Bisilicate of Magnesia*; and Mr. Shepard, with reference to its locality, calls it *Boltonite.*[*] It occurs in foliated masses in the limestone. (Nos. 521, 522.)

In the same place, at the south quarry, sphene, or silico-calcareous oxide of titanium is not an uncommon ,mineral in distinct crystals. Tremolite, also, is said to occur there in fibrous masses: also gadolinite, according to Professor Webster: also talc in veins, as well as at Littleton.

Very delicate and beautiful amianthus is found in veins in the limestone, about two miles southwest of the centre of Chelmsford. The fibres are sometimes two or three inches long, and resemble the finest and most beautiful white silk. The same mineral in small quantities is found at Bolton. (Nos. 523, 524.)

In season for the second edition of my Report, I have received from Dr. Charles T. Jackson, a full account of several interesting minerals found at the limestone quarries above described; and I am happy to have the opportunity of annexing it to the preceding statements, for the most part in that gentleman's own language.

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[*] Shepard's Mineralogy, Vol. I. p, 232.

Perhaps the most interesting mineral found at these quarries is the spinelle, especially the ruby; and it ought here to be mentioned that its discovery was made by Dr. Jackson, in 1824, and not by Prof. Nuttall, as is usually stated. Besides the localities of spinelle mentioned below by this gentleman, I ought to state, that the pleonaste occurs at Acton, both massive and in regular octahedra.

'The ruby from Bolton,' says Dr. Jackson, 'is of a delicate rose red, and will come under the head of Balass ruby. It generally occurs in flattened octahedra with cuneiform summits produced by the lateral elongation of the octahedron. It serves perfectly well for cutting glass, and in the place of the writing diamond. I have given a few crystals to Mr. J. Bigelow, who has used them for jewelling watches. The crystals are easily detached from the matrix by means of muriatic acid, which dissolves away the lime.

'I have several doubtful minerals from Bolton, which I shall this summer endeavor to determine. Those that are pretty well determined are the following.

'At Bolton in granular limestone imbedded in gneiss, *Allanite*: it occurs in the petalite in quadrangular rhombic prisms.

'*Yttro-cerite?* in rhombic and six sided prisms. I found a crystal of this mineral one fourth of inch an long in the petalite.

'The above occur at Hildreth's quarry.

'The following were found at Whitcomb's quarry, situated about one eighth of a mile from the former, and still explored for limestone.

'*Magnesite, Potstone, or compact talc:* in veins and nodules three or four inches thick, associated with talc and rhomb spar.

'*Serpentine.* It occurs in rhombic crystals which may easily be measured by polishing the limestone in which it occurs, transversly across the extremities of the crystals. This mineral is found in considerable quantity. The best specimens are found in a heap of refuse limestone rock, between Hildreth's and Whitcomb's quarry. The polished specimens are very handsome, and might be used for ornamental purposes. It is fully equal to the verd antique in beauty. Slabs three feet in length may easily be sawed out. The serpentine is of a bright green color, and when broken, has a conchoidal fracture and waxy lustre.

'At Littleton I found the following minerals in the limestone of that place, which is a bed in gneiss, like that in Bolton, and occurs near a little lake, called fort Pond.

'*Scapolite* in large prismatic crystals, from one and a half to two inches in diameter, and seven or eight in length. It occurs in greasy quartz. The scapolite occurs also massive in veins, and in a compact form of a beautiful lilac color.

'*Petalite* of a reddish tinge. *Augite and Sahlite. Spinelle Pleonaste, SpinelleRuby,* and a very handsome *hair brown Spinelle,* in limestone. The spinelle is associated with nodular *Garnet* and *Pargasite. Serpentine,* sometimes crystalized in rhombic prisms. *Pyrallolite* of a grayish blue color, but it becomes changed to yellow by the action of the weather, as it does before the blowpipe. (Boltonite of Shepard? E. H.) *Sphene* like that of Bolton.

'At Boxboro' the bed of limestone, like that in Bolton, occurs in gneiss. It contains nearly all the species found at Littleton, and furnishes besides the most perfect specimens of a beautiful wine yellow garnet, which has been called cinnamon stone. It is difficult to obtain perfect crystals, although those with two or three faces of the rhombic dodecaedron are easily obtained. Some in my possession measure an inch across the planes. Boxboro' furnishes the best crystals of brown spinelle, of pleonaste, and of the granular Pargasite.

'At Chelmsford, the limestone, still in gneiss, occurs in several beds near each other. In this limestone, in 1825, I discovered a fine sapphire blue spinelle, associated with tremolite. The crystals were one fourth of an inch in length, transparent, and clear of all imperfections. Having never seen this variety, I named the specimens which I sent abroad, *Spinelle Sapphire,* or *Coerulean Spinelle.* They frequently occur in octahedra, laterally elongated, with wedge shaped summits. I found, also, at Chelmsford, nearly all the minerals which occur in Bolton. Black spinelle frequently occurs, as at Boxboro' and Bolton, associated with chondrodite, of an orange yellow or deep blood red color. I have a fine specimen of asparagus stone, which I found at Bolton, two inches long and one fourth of an inch in diameter. It is a six sided prism, and of a beautiful bluish green color, with very brilliant sides. Its gangue is calc spar, associated with scapolite and sphene in large crystals.'

Limestone in Smithfield, R. I.

There are two principal beds of this rock, a little more than a mile apart; the most easterly one, half a mile from Blackstone river, being called the Dexter rock, and the other, the Harris rock. I have examined only the latter; and this occurs in that variety of hornblende slate, which the Werenians call greenstone slate, and transition or primitive greenstone. The slaty structure of a part of the rock is quite obvious, though to a cursory observer, most of the mass resembles very much secondary greenstone. I am satisfied that the Dexter rock occurs in the same slate, which in fact, appears to be the talco-chloritic slate of that region, passing into hornblende slate. Though the parallel division, of the hornblende slate be evident, yet the limestone is destitute of stratification; forming an irregular mass, penetrated by projections from the slate. It is white and distinctly, though not very coarsely granular and crystalline. Some of it is dolomite. (Nos. 498 to 500.) It may be, and has been wrought as marble; though it is difficult to obtain large blocks without fissures. Sometimes it is clouded. (No. 497.)

The imbedded minerals in this limestone are, with few exceptions, very different from those just described in the limestone beds in gneiss in Massachusetts. In the Smithfield rock, talc is one of the most abundant of the minerals, and it is often of a rich silvery white color, associated with large prisms of rhomb and calcareous spar. Some of the nacrite found at the Dexter rock is beautiful. Nephrite exists here, also, in veins and nodules: also limpid quartz in crystals, calcareous and brown spar, tremolite and asbsetus.

If, as seems to me extremely probable, the hornblende rock in which this limestone occurs, has been subjected to the action of powerful heat, we have a cause for the want of stratification in the latter. And the occurrence of immense quantities of sienitic granite in the vicinity, shows us whence the heat might have been derived.

Limestone of Stoneham and Newbury.

In both these places the limestone is in irregular unstratified masses in sienite, except that the most northerly bed in Newbury is in greenstone. For the most part, the limestone is either finely granular, or compact, and white. That at Stoneham is translucent on the edges; (No. 496.) and were it not for the numerous seams and cracks in it, would prove a very fine article for statuary and other ornamental purposes. Two or three quarries have been opened at each of these localities, only a few rods apart; but they are now abandoned. At Newbury, the great amount of foreign minerals present renders the limestone of little value, even for the production of quicklime.

Among these minerals precious and common serpentine predominate: and these being disseminated in the granular limestone, form the *ophicalce grenue* of Brongniart,* which he mentions as occuring at Newbury.† Specimens of this variety may be seen among those that are polished in the collection; (Nos. 896 to 899,) although the geological position of this rock, if I have not mistaken it, is not above organic relics (*épizoïque*) as that author supposes it commonly is.

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* Classification des Roches, p. 96.

† Tableau des Terrains. &c. p. 325.

Another beautiful mineral, often running in veins through the *ophicalce grenue*, or the serpentine, varying in width from a mere line to half an inch, is green amianthus. When a specimen is newly fractured, this mineral presents a peculiarly rich appearance. Its color is grass green and yellowish green. (No. 872.) Common asbetus occurs in the same situation.

Fibrous limestone, or satin spar, occurs in the same connection. The fibres are sometimes four or five inches long, though the veins of this mineral are quite thin.

Tremolite in radiated masses is not uncommon in this limestone. Epidote also occurs here in crystals; and white and gray varieties of compact feldspar. Associated with the tremolite and epidote, is found massive garnet.

The limestone at Stoneham, is not so much mixed with other minerals as at Newbury. It occasionally, however, contains nephrite. This mineral melts with great facility before the oxy-hydrogen blowpipe, and without difficulty before the common blowpipe, into a yellowish slag or scoria. Another grayish green mineral occurs in nodules in the limestone, and might easily be mistaken for the siliceous infusible mineral that has been described by many writers under the name of hornstone. But it melts with ebullition, not only before the compound, but also the common blowpipe, into a shining black enamel. (No. 507.) It is probably the allochroite, mentioned by Prof. Webster in the Boston Journal of Philosophy, as occurring at Stoneham.

I am not aware that limestone has been found in other parts of the world, entirely embraced in sienite; which is the case at Stoneham and Newbury, unless I am mistaken. At the time I examined these localities, I was not aware of the importance of this fact, and might have been deceived. But I saw no rock in the vicinity of the quarries, except sienite: although, as I shall have occasion hereafter to observe, sometimes the sienite north of Boston possesses a limited slaty structure, forming a kind of hornblende slate, or greenstone slate: the unmelted remnants, perhaps, of the rocks out of which the sienite was formed. That this rock had an igneous origin, seems to be at this day the opinion of geologists. And admitting this, it is easy to see why the beds of limestone, that have been described above, are destitute of stratification.

Origin of Limestone.

Crystalized carbonate of lime, as we are taught by chemistry, may be produced either by precipitation from aqueous solution, or by the melting of uncrystalized masses of this substance under strong pressure: and probably in both these ways are we to account for the existence of primary limestone. Where this rock is in regular strata, and no unstratified rocks exist in the vicinity, it is reasonable to refer its origin to aqueous solution and crystallization. But where there is evidence of the agency of heat, long continued, in the irregular position and unstratified structure of the limestone, and the juxtaposition of granite, trap, &c.; it is not improbable that limestones deposited from water or animals, such as chalk, marl, compact limestone, and coral reefs, may have been melted and subsequently crystalised.

Thus far most geologists agree. But another point divides them; viz. whether all limestones have originated in organized substances? Dr. Macculloch[*] leans to the affirmative: but another able geologist, Mr. Lyell,[†] defends the negative. Mr. Lyell, however, does not object to the idea that 'every particle of lime that now enters into the crust of the globe, may possibly in its turn have been subservient to the purposes of life by entering into the composition of organized bodies;' but to the opinion that 'lime may be an animal product combined by the powers of vitality from some simple elements.' Dr. Macculloch thinks his views of the subject rendered probable, by the great increase of calcareous strata, the higher we rise in the series of formations, and by the great extent of existing coral reefs. But Mr. Lyell says that in ponds or lakes, which are not fed by springs containing carbonate of lime in solution, there will be no accumulation of shells producing tufa and shell marl: one race of animals furnishing by their decomposition only calcareous matter enough to supply the next generation; and hence he infers that the animals do not secrete lime. And he explains the greater quantity of calcareous matter in the newer strata, by the constant transfer of this matter from the inferior to the superior rocks by internal heat and springs.

But however, this point may be decided, it is certainly an interesting thought that all existing limestone may have once formed a part of organized beings. That much of it in the secondary rocks did enter into the composition of animals, is obvious from the immense quantity of their remains now found in such rocks. But why are the primary rocks destitute of them? Dr. Macculloch says that he has found organic remains in one instance, 'in a calcareous quartz rock situated beneath gneiss.' But he has also shown conclusively that limestones full of organic remains, when in contact with trap, are converted into highly crystalline masses, and the organic remains entirely obliterated for a certain distance from the trap. Such a change he supposes may have been undergone by all the primary limestones.

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[*] System of Geology, Vol. I. p. 220.
[†] Principles of Geology, Vol. II. p. 298. London, 1832.

It is well known that calcareous soils are of all others most fertile. Now if it be true that the quantity of limestone on the globe is increasing, it will follow that there is a progressive increase of fertility. Such a view would certainly accord with our ideas of divine beneficence: but we should not forget the danger of hasty inferences on such subjects.

8. SCAPOLITE ROCK.

Associated with the limestone and mica slate of Berkshire county, which extend into Canaan, Ct., extensive beds or strata occur, composed essentially of what I suppose to be compact scapolite. I have traced these strata in the town of Canaan, from six to eight miles in length, and in some places from 100 to 150 rods in breadth. And I have no reason to doubt but they extend much farther in length; probably into Massachusetts on the north; and I cannot judge how far south. No one, it seems to me, could regard masses of such extent and regularly stratified, only as a simple mineral. And if I am not mistaken as to its nature, there can be no doubt it is a new rock; since in other quarters of the globe, scapolite is rare even as a mineral. I thought at first that it might be a compact variety of white augite; since this mineral does occur in connection with the same limestone. But the rock fuses with intemuscence and without difficulty into a white enamel: whereas I could not melt the augite from the same locality. The following are all the varieties of this rock which have yet fallen under my notice.

1. *Masses exhibiting Aggregations of imperfect Prisms of Scapolite*; too imperfect, however, to determine their form, though the foliated structure is quite obvious. This rock is liable to partial decomposition at its surface. I have found it only in bowlders. (No. 540.)

2. *Compact gray Scapolite*, exhibiting a splintery fracture. This is the most common variety. It is very perfectly stratified in most instances, the strata varying in width from half an inch to a foot or more. Generally the surface is partially decomposed to the depth of more than half an inch, resembling some varieties of amygdaloid, or variolite. On account of the evenness of its stratification, it forms an excellent building stone, and is employed for this purpose by the inhabitants of Canaan. Not unfrequently these strata are divided by seams crossing the regular planes of stratification nearly at right angles. (No. 541.)

3. *A mixture of Scapolite and Dolomite.* The proportion of the two minerals is various. The limestone is most liable to decomposition and leaves the scapolite in irregular masses; giving to the rock a most forbidding aspect. (No. 542.)

4. *Compact Scapolite, Quartz, and Mica.* (No. 543.) This appears to be mica slate or quartz rock containing a small proportion of scapolite.

5. *Granular Quartz and Scapolite;* containing also tremolite and augite. (No. 544.) This variety is scarcely worth noticing.

The strata of scapolite rock in Canaan run in a direction not far from northwest and southeast, and dip to the northeast at an angle generally as great as 45°. The principal part of the rock seems to lie between the dolomitic limestone beneath, and the mica slate above, which forms lofty ridges of mountains in Canaan. I saw none of the scapolite rock in place, however, more than 200 feet above the limestone, though bowlders of it are frequently met with on the mountain east of South Canaan meeting house to its summit, on the road to Norfolk. I did not see the actual junction of the mica slate and scapolite rock, but the dip and situation of the two rocks renders it almost certain that the latter does pass under the former. On the lower side, the scapolite rock passes by a gradual mixture into the limestone: as the specimens will show. Upon the whole, the age of this rock is the same as that of the Berkshire limestone, which alternates with mica slate; and which probably is not as old as that which alternates with gneiss.

It will be seen that the preceding description of this rock does not differ—except in being more extended—from that which I gave in 1828, in the 14th Vol. of the American Journal of Science. If I could have referred it to any known group of rocks, I should not have described it as new. But this was impossible.

9. QUARTZ ROCK.

Among the older rocks geologists have not been able to discover any determinate order of superposition; although each one of them is most likely to be found in in a particular connection. But the same rocks are also found in several other connections, so as to render all attempts to fix their exact place in the scale unsatisfactory. Our rocks are as unmanageable in this respect as those in Europe, but no more so; showing that the same general causes have produced them on both continents. I have already shown that our limestones are of various ages, and the same is true of quartz rock, hornblende slate, and some others. Amid this great uncertainty, as to the place in the series which the older rocks ought to occupy, it is not easy to decide what is the best order of describing them. It will be observed that I do not follow exactly the same order in the account of the rocks which I am now giving as is followed in the tablets attached to the Map. The order

order which I now follow, and which agrees with that given on the Tabular View of the Rocks in the Atlas, accords, as nearly as I can determine it, with the order of nature: whereas on the Map, I was obliged to have some reference to convenience of exhibition; one of the groups being miscellaneous.

Mineralogical Characters.

Quartz rock was first described by Dr. Macculloch; and its chief ingredient, as its name implies, is quartz. But it takes into its composition, mica, feldspar, and sometimes blue schistose clay. The following varieties are found in Massachusetts.

1. *Pure Quartz.* This exists in several states. First, hyaline, white: generally in beds in mica slate. Secondly, compact, white, or reddish, or dark blue; in beds in argillaceous slate. It is quite obvious that this blue variety has, in some way or other, been coloured by the slate; either when first deposited from aqueous solution, or when subsequently melted, if it ever has been, by heat. Thirdly, coarse, granular, color gray, or reddish. These are the most common varieties. Fourthly, fine, granular, or arenaceous; sometimes disintegrated so as to form a beautiful white sand. (Nos. 545 to 565.)

2. *Granular Porous Quartz,* with occasional fragments of foliated feldspar and black hornblende. This is the rock described in the first part of my Report, under the name of buhrstone; for which it is used. It is certainly a remarkable rock. Without close inspection it would not be distinguished from the Paris buhrstone. But it is in fact finely granular; and what is most remarkable, is the occurrence in it of occasional fragments of foliated feldspar and hornblende, rarely larger than a pea, and often not larger than the head of a pin. These have evidently been subjected to attrition; and they give to the rock somewhat of a mechanical texture. I have observed also in this rock, traces of mica slate; and the longest direction of the pores corresponds with that of the strata seams, and gives the rock a slight claim to a slaty structure. The pores or cavities are rarely large, but they are disseminated through the whole rock; and are most frequently coated with a yellowish substance, which may be hydrate of iron. The quartz in these cavities is slightly mamillary, sometimes showing a tendency to crystallization. (No. 567.)

3. *Quartz and Feldspar;* the former in much the largest quantity. This variety usually occurs in connection with gneiss, and not in large quantity. (Nos. 571, 593, 600.)

4. *Quartz and Mica.* This differs from mica slate, only in the predominance of the quartz. Usually this mineral is greatly in excess: but occasionally the quantity of mica increases so much, that it is impossible to say of particular specimens to which rock

they ought to be referred. In such cases I have taken into consideration the character of the surrounding region. If mica slate predominates, and there be not an actual passage into decided quartz rock, I have thought it useless to describe the rock as quartz rock, even if for a considerable extent the quartz predominates. Such cases as this are common in the mica slate range extending from the mouth of the Merrimack to Connecticut. And on the other hand, if quartz rock predominates, an occasional excess of mica in some of its strata has not prevented me from considering the whole as quartz rock.

The mica in this variety is arranged in a parallel position, and it produces a schistose structure; though sometimes the laminæ are so thick that they ought rather to be regarded as strata. In other instances, the schistose layers are extremely tortuous and very distinct from the stratification. I have observed this circumstance only in Berkshire county, as in Lee. (Nos. 572 to 580; and 587 to 592.)

5. *Quartz and Talc.* Some of the talcose slate in Hawley, Plainfield, &c., occasionally becomes a slaty arenaceous quartz, with seams of greenish talc. (Nos. 581 to 583.) Its color is white, and this rock, in Hawley and Rowe, seen at a distance, resembles gneiss. It is obviously a member of the talcose slate formation; and it may be questionable whether it ought not rather to be described in connection with that formation.

6. *Quartz and Hornblende.* Instead of talc, the white arenaceous quartz described under the last variety, sometimes contains numerous distinct crystals of black hornblende. (Nos. 584, 585.) It forms a beautiful rock, and if it would admit of a polish, might be employed for ornamental purposes. It is less abundant than the preceding variety. In the gneiss formation, there is a variety in which greenish hyaline quartz contains flattened imperfect crystals of actynolite. (No. 584.)

7. *Quartz and Argillaceous Slate.* I have observed this only in Bernardston, in connection with the encrinal limestone. (No. 601.) The quartz is white and blue, and exhibits a brecciated structure. It was probably colored by the slate; but very few fragments or layers of slate are now visible.

8. *Quartzose Breccia.* This consists of angular fragments of granular quartz, connected by oxide of iron; or of fragments of mica slate, surrounded by radiated quartz. The variety found in bowlders in Leverett and Amherst, (I have no doubt that the bed from which they were derived is in Leverett,) contains but very little iron, scarcely more than enough to give a part of the fragments a reddish hue. (Nos. 602, to 608.) Another variety I have found in Amherst, in connection with the gneiss formation, in which the cement is magnetic oxide of iron. But the most

interesting variety exists in numerous bowlders along the western slope and base of Hoosic mountain. It consists of angular fragments of white and reddish granular quartz cemented by brown hematite. (Nos. 604 to 606.) In the cavities the hematite is often iridescent and mamillary; and the coat investing the fragments, fibrous. The largest bowlders of this rock that I have seen, (six to eight feet in diameter,) occur on the Pontoosic turnpike from Pittsfield to Springfield, in the south part of Dalton, at the foot of the Hoosic range. But I have never found this rock in place. It may be that the loose fragments have all proceeded from a huge vein of this breccia. But from their size and abundance, I rather presume that this rock will be found as a bed in the common granular quartz of the vicinity. I found one bowlder of this rock ten inches in diameter, in Southampton; only two or three miles from Connecticut river; affording another proof of a northwesterly diluvial current in former times.

Professor Dewey remarks, that in Great Barrington and Sheffield the fragments of quartz are united by a cement of quartz.

The most common gangue of the lead and manganese ores in Hampshire and Franklin counties, is quartz. In a majority of cases it is radiated quartz investing nuclei of micaceous slate. Thus is produced a very curious kind of breccia. (No. 608.) And since these veins are sometimes six or eight feet thick, the quantity is great enough to deserve a notice in this connection.

9. *Quartzose Conglomerate.* This consists of a paste of quartz and mica, in which are imbedded numerous distinctly rounded pebbles of granular or hyaline quartz. (Nos. 609, 610.) It possesses as completely the characters of a conglomerate as any of the puddingstones of the secondary formation. I have never found it in place; but cannot doubt that it is associated with the quartz rock of Berkshire county. For its bowlders are not uncommon on the west slope and the top of Hoosic mountain. In Windsor I found them unusually abundant. I have even found small bowlders in the Connecticut valley, in Deerfield. It appears to be identical with the Conglomerate Quartz Rock of Macculloch.* The size of the imbedded pebbles is usually about an inch. It greatly resembles the rock that constitutes the first ridge of the mountain range on the east side of Wyoming valley, in Wilksbarre, Pennsylvania; and which there probably underlies the anthracite coal formation.

This rock, being most decidedly mechanical in its texture, will throw some light on the age of the quartz rock, and associated limestone of Berkshire valley, if it be admitted that it forms a part of the series; of which I think there can be but little doubt.

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* Geological Transactions, Vol. I. p. 60. Second series.

It will be perceived that the varieties, Nos. 5, 6, and 8, above described, are different from any mentioned by Dr. Macculloch, and so far as I know, by any writer.

In order to have a complete view of quartz rock, as it exists in Massachusetts, we ought to recollect that two varieties (red and blue,) have already been described as comprehended in the graywacke formation.

Topography of Quartz Rock.

On the Map I have represented all the quartz rock in the State (excepting that connected with the graywacke,) as associated with mica slate, talcose slate, or gneiss. It is also more or less connected with other rocks; as with limestone in Berkshire, and with argillaceous slate in Bernardston. But in all other cases, except in regard to gneiss and mica slate, it is little more than a juxtaposition of the two rocks; whereas the quartz rock alternates with, and passes imperceptibly into, gneiss and mica slate. And in fact it might be regarded very properly as a member of the gneiss and mica slate formations.

In Cumberland, Rhode Island, I have marked a strip of quartz rock as connected with the peculiar rock that prevails in that place, and which I venture to denominate talco-chloritic slate; although its characters are very obscure. Or rather the quartz rock lies between this slate and the graywacke on the east; and I think also that it alternates with the talco-chloritic slate. In the northeast part of the town, it forms a hill of considerable altitude, of snowy whiteness. More westerly its color is gray, and it is of a coarser texture.

I take this opportunity to remark, that I do not feel confident that even on the third edition of the geological Map, and after a re-examination of that region, I have correctly delineated the rocks of Cumberland and its vicinity. Its geology is certainly very intricate, and deserves the long and careful study of some one who resides in the vicinity; and then it should be exhibited on a map of a larger scale than mine. Since it is not in Massachusetts, I did not feel justified in devoting so much time as was desirable to its examination.

The range of mica slate extending from Webster to the mouth of the Merimack, often passes into genuine quartz rock, and generally contains a large proportion of quartz. In the south part of this range, in Webster especially, I noticed so much quartz rock that I have represented a patch of it on the Map.

The gneiss formation on the east of this mica slate, especially near the south part of Worcester county, is associated with extensive strata of quartz rock. In Sutton, and the vicinity, the latter occupies a considerable part of the surface; and there I have delineated this rock on the Map. I have noticed it in several of the towns northeast from Sutton, interstratified with gneiss and hornblende slate. In the eastern part of Franklin county, in New Salem and Warwick, I have met with it in strata of a few feet wide interstratified with gneiss.

Along the western border of the great gneiss range of Worcester county, is another narrow stratum of quartz rock, in some places associated with the gneiss, sometimes with hornblende slate, and sometimes with mica slate. I have represented it on the Map, as extending only from Leverett to the north line of the State, because south of this place it is very narrow and frequently interrupted. Mica slate is commonly associated with this rock north of Leverett. On the opposite side of Connecticut river, in Northfield, Mass. and Vernon, Vt. quartz rock forms one of the members of a series of mica slate passing into gneiss, hornblende slate, and argillaceous slate. In Vernon it is liable to disintegration and has been employed for the manufacture of glass. In Bernardston, where it approaches the clay slate, as already remarked, it occasionally takes portions of that rock into its composition. But generally in Leverett and Northfield, it is that variety which contains mica.

Berkshire county, however, contains the principal repository of quartz rock. Here it is usually associated with mica slate; and although it is represented as lying contiguous to gneiss, yet I have given my reasons elsewhere for the opinion that its position is unconformable to that of the gneiss. It sometimes forms hills of considerable elevation: as Monument mountain, in Stockbridge, which is more than a thousand feet high. Compared with the mica slate and gneiss, however, this rock lies generally at a low level; corresponding in this respect with the limestone. The largest proportion of this rock is gray or reddish granular quartz. In Cheshire, it is extensively disintegrated, so as to form a good sand for the preparation of glass. For the cause of this disintegration I have sought in vain. The buhrstone in Washington, near Pittsfield, is another interesting variety; and in the same hill, the granular quartz is quarried extensively for architectural purposes, on account of the great regularity of its stratification. I observed the variety containing mica, in Lee, Washington, Canaan, Ct., &c.; though this is not the most common variety. The situation of the breccias and conglomerates has been already pointed out.

It is also unnecessary to say anything farther in relation to the quartz rock containing talc and hornblende.

In connection with the gneiss in the southeastern part of the State, it may be remarked, that quartz rock occurs in considerable quantity, as I have noticed in several places, having an agatized structure. That which I found in Rochester, is quite beautiful, (a polished specimen of which may be seen in the collection.) Some examination since the publication of the first edition of the first part of my Report, has led me to suspect that this quartzose aggregate is more abundant and extensive than I had supposed; perhaps extensive enough to deserve a place on the Map.

Dip, Direction, and Character of the Strata.

It requires in many cases careful attention to discern seams of stratification in the purely granular quartz of Berkshire county. They are never, however, wanting for any considerable extent. And very frequently there exists a set of cross fissures, nearly at right angles to the planes of stratification. The same thing is true of the quartz rock of Leverett and Northfield, in which mica is sparingly interlaminated. (No. 577.)

In general, however, quartz rock exhibits great distinctness and regularity of stratification, particularly the variety last mentioned. Where the mica is in small quantity, the thickness of the strata is considerable; but as the mica increases, the layers are thinner, until at length the rock becomes schistose. At the quarry in Washington, near the buhrstone locality, the stratified structure is beautifully exhibited; and it results from a minute quantity of mica, in scales scarcely visible to the naked eye. The stratification of the buhrstone, which lies at the northern extremity of the same elevation, is much less distinct. But immediately beneath this variety, the rock takes so much mica into its composition as to become slaty,—almost mica slate even. (No. 591.)

In general the dip and direction of the strata of this rock correspond to those of the gneiss and mica slate with which it is connected. In Berkshire I have already remarked that the direction is usually north and south, and the dip east, at rather a small angle. At the quarry just mentioned, however, the dip is form 10 to 15° westerly; but the buhrstone dips about as much in the opposite direction. And in the quarry we find veins of granite, indicating the proximity of a larger mass of that rock; though I did not explore the surrounding region for it: but I think this fact will afford a probable explanation of this anomaly in the dip of the strata. In the northeast part of Windsor, high up the Hoosic range of mountains, this rock dips north about 25°.

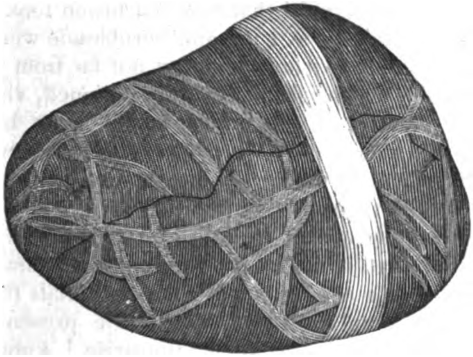
The quartz rock in Northfield and Bernardston, west of Connecticut river, dips from 20 to 60° east, and runs north and south. East of the river, its dip approaches 90° east. In Southborough its direction its nearly east and west, and its dip northerly and large. In Oxford and Webster, its direction is nearly north and south, and its dip from 20 to 45° west; though in the west part of Oxford I noticed a dip of 10° easterly, the rock being interstratified with gneiss. In Sutton the dip is from 30 to 35° north, corresponding to that of the gneiss in the vicinity.

Mineral Contents.

Scarcely any rock in Massachusetts, is so destitute of simple minerals as this: unless we include in it those metallic veins of which quartz is the gangue. But these may more appropriately be described under granite; in which rock these veins for the most part occur. Hematite iron ore, forming the cement of the quartzose breccia in Dalton, is the most interesting mineral in the quartz rock. Sulphuret of iron, also, has been observed in small quantities in that quartz rock which is associated with talcose slate in Hawley, &c. In Pittsfield, Worthington, &c., masses of quartz are found of a yellowish color, and appear to be genuine ferruginous quartz. Sometimes this quartz passes into yellow jasper, and also into chalcedony and hornstone as at Dalton.

Veins in Quartz Rock.

In a few instances, as at the quarry of quartz rock in Washington, several times spoken of, veins of granite may be seen. But generally the veins in quartz rock are quartz; the vein being usually white and opaque, and the rock a mixture of gray quartz and mica,—the latter mineral existing, however, in very small proportion. In some instances the rock appears to be what the Wenerian writers denominated primitive siliceous slate. The following is a sketch of a bowlder of about eight inches diameter, found in Amherst. The principal part of it is gray quartz traversed by numerous veins of white quartz.



Quartz Veins in Quartz Rock.

Theoretical Considerations.

The regularity of the stratification in quartz rock, and the fact that silica is soluble in water, have disposed geologists, in all cases where it is possible, to impute to this rock an aqueous origin. But like all the older rocks it appears subsequently to have been subjected to heat of a greater or less degree of intensity, whereby it has been rendered compact. And no doubt in this way some siliceous sandstones have been converted into solid quartz: as in the Isle of Sky, in Scotland, where trap comes into contact with the sandstone.

A complete theory of the formation of that variety of brecciated quartz, which in Dalton is cemented by hydrate of iron, it is not easy to form. The chief difficulty seems to be, to imagine how the quartz was broken into such numerous angular fragments: for after these fragments were piled together, it is not difficult to conceive that the interstices might have been filled by the iron from solution in water.

The same difficulty occurs in the case of those extensive metalliferous veins that have been referred to, whose gangue is quartz, enclosing masses of mica slate and forming a kind of breccia. But the whole subject of mineral veins has a great deal of mystery hanging over it, and is probably less understood than any other department of geology.

What shall I say of the origin of the Washington buhrstone? We have every reason to conclude that the French buhrstone was deposited from water. And that at Washington differs from it chiefly in being more arenaceous and tender. Probably, therefore, it had a similar origin. But what shall be said of the occasional *fragments* of feldspar and hornblende which it contains? Certainly these give it somewhat of a mechanical character, and their production and introduction are difficult to explain. Can it be, that subsequently to its deposition, it has been subject to the action of a heat so powerful that a partial fusion took place, and a few imperfect crystals of feldspar and hornblende were thus produced? The granite exists in quantity not far from this rock, is rendered probable by the facts already mentioned, viz. that veins of it occur at a quarry of quartz rock in the same hill, and that the strata at this quarry dip a few degrees to the west, while the buhrstone dips about as much to the east. And this granite might have furnished the requisite heat.

The conglomerate quartz rock originated probably like other conglomerates; that is, we must first suppose an abrasion of existing strata, and then a consolidation of the materials thus worn off, either by heat or simple dessication. In the present case, heat was probably an important agent. Otherwise I know not how to explain the marks of a crystalline structure which it exhibits; as much, indeed, as the oldest mica slate. But until this rock is found in place, it will be useless to spend much time upon its theory.

The varieties of quartz rock associated with mica slate, talcose slate, and gneiss, probably had an origin similar to that of these several rocks. That they have all been acted upon powerfully by heat, I cannot doubt; but not until after their deposition. I confess myself inclined to the opinion, that all these strata originally resembled our present secondary strata; and that the agency of the unstratified rocks has rendered them crystalline. Thus the quartz rock that contains some mica, might have been originally a micaceous sandstone. But more of this hypothesis as we proceed.

It is gratifying to find that the quartz rock of Massachusetts corresponds so closely with that of Europe. But we shall find this to be the case generally with our primary rocks; a proof of uniformity in the mode of their production.

10. MICA SLATE.

It is usual to place this rock next to gneiss, or as the second in respect to age among the stratified rocks. And in Massachusetts it is not unfrequently associated with gneiss. But it is also associated with every other rock, as high in the series at least as argillaceous slate: I mean in a conformable position. Hence I have thought it best to introduce it before talcose and hornblende slate and serpentine; because these latter rocks, in the district under consideration, are connected, scarcely without an exception, only with gneiss and the oldest varieties of mica slate.

Mineralogical Characters.

It is hardly necessary to remark, in respect to a rock so common and well known, that its essential ingredients are quartz and mica: and the anomalies of composition are fewer in this rock than in most others; although the varieties of aspect are numerous. As I understand the subject, however, it is necessary that the mica should be the predominant ingredient, in order to constitute a rock mica slate. But in this case we must look to the whole mass of the rock, rather than to hand specimens: for single specimens may often exhibit the quartz in excess, and yet be regarded as mica slate. The following varieties of this rock I have found in Massachusetts.

1. *Quartz and Mica:* the former granular and laminar; the latter in distinct scales and highly glistening. This variety is associated with the oldest rocks, as granite and gneiss; and is obviously more highly crystalline than the other varieties. The longitudinal arrangement of the mica gives this variety sometimes a fibrous appearance. (Nos. 614 to 626.)

2. *The same, containing a small proportion of Feldspar,* and thus passing into gneiss. (Nos. 627 to 636.) It is only when the mica greatly predominates that this rock can with any propriety be denominated mica slate.

3. *Passing into Talcose Slate.* In most cases the mica slate under this variety, takes into its composition scales of greenish talc. But sometimes, I apprehend, the mica becomes tender, almost losing its elasticity, and very much resembling talc, from which it is scarcely posssible to distinguish it. When the talc predominates, especially to the exclusion of the mica, the rock then becomes talcose slate. (Nos. 637 to 641.)

4. *Amphibolic and Garnetiferous Mica Slate.* This variety takes into its composition in large proportion, hornblende or garnets; usually both. From the fact that those minerals are commonly found together, I have made only a single variety include them both. (Nos. 642 to 645.)

5. *Staurotidiferous Mica Slate.* In this rock the mica is in very fine scales, and has the general aspect of argillaceous slate; except that when the strata are viewed edgewise, they exhibit a striped appearance, in consequence of numerous layers of staurotide, which appear to be co-extensive with the layers of the rock. I should not have regarded this mineral as of importance enough to constitute a distinct variety of mica slate, did I not know that extensive ledges, like the rock just described, extend nearly across the whole of Massachusetts, through the towns of Norwich, Chesterfield, Goshen, Hawley, and Heath; and on the east side of Connecticut river, it has been traced, with some interruptions, from near Long Island Sound to Franconia, New Hampshire, a distance of nearly 200 miles. Where it crosses Massachusetts, however, it is but imperfectly developed. (No. 646.)

I wish here to remark, that when I coin a new term to prefix to a variety of rock, it is rather for the sake of giving a laconic definition, than in the wish or expectation that it will become a permanent name for the rock. Indeed, mere varieties need no distinct names, except when an attempt is made to give a logical account of a formation.

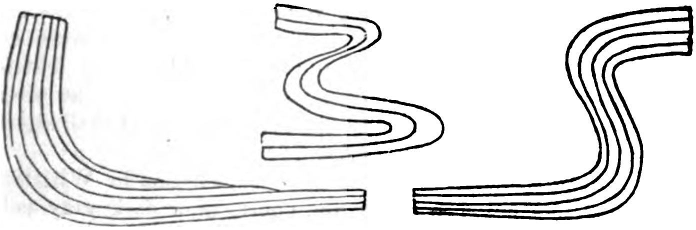
6. *Spangled Mica Slate.* The basis of this singular rock is the same as in the last variety; and the two are associated in Chesterfield, Goshen, Plainfield, &c. Through this base are disseminated numerous thin foliated plates of a deep brown color, resembling mica somewhat, but almost entirely destitute of elasticity and brittle. Their length, (rarely more than a quarter of an inch,) is usually twice as great as their breadth, and there is a decided polarity exhibited in their arrangement: that is, their longer axes all lie in the same direction, and the surfaces of the plates in the same or in parallel planes; so that light is reflected from many

of them at once when the specimen is held in a proper position, and thus a beautifully spangled appearance results. Not being confident as to the nature of this mineral, I have given the rock a designation which indicates merely this obvious property. These spangles are pretty uniformly diffused through the mass, and their surfaces rarely coincide with the layers of the slate. (Nos. 647 to 650.)

I found this same rock in rolled masses in Newport, R. I. And Col. Totten informed me, that it exists in place on one of the islands in Narraganset bay,—Canonicut Island I believe. At Plainfield it is sometimes divided into rhomboidal masses by oblique cross seams. (No. 649.)

7. *Argillo-micaceous Slate.* This exists wherever the mica slate passes by gradation into clay slate: and such places are numerous in Massachusetts. It exists also, in connection with the two last varieties, in the range of slate passing through Chesterfield, &c.; where the strata are perpendicular, and have a broad range of decided mica slate on the east, and a similar extent of talcose slate, hornblende slate, and gneiss, on the west; which position is strong evidence that this rock must be one of the oldest of the primary strata. It does not, however, in this case actually pass into clay slate. And I believe it will always be found to consist of fine scales of mica, closely compacted, so as to give it an argillaceous aspect. This rock sometimes contains large beds of white quartz, which is frequently fetid. (Nos. 651 to 667.)

8. *Arenaceous Mica Slate.* In this variety the quartz is gray, in fine sandy grains, and diffused through the whole mass, not lamellar. (Nos. 668 to 712.) The mica is in fine disseminated scales; although the plates are usually parallel to one another. The mass is usually imperfectly schistose, though more regularly stratified than most other varieties; and sometimes there exists a double set of strata seams. Ordinarily it is not so much contorted in its layers as the older varieties; but an intermediate variety is perhaps of all the mica slates most remarkable for irregularity. The following are sketches of the curvatures, in Nos. 688, 689, and 690, which are from the Gorge or 'Glen' in Leyden.



In Norwich and Enfield this variety has been extensively employed for whetstones: the former locality is far the best, and the latter is now nearly or quite abandoned.

In general this variety occupies the highest place in the mica slate series. Thus we find it on both sides of the valley of the Connecticut, when first we pass on either side of the river from the new red sandstone; and the whole of the mica slate formation in Worcester county is of this description.

This variety is very nearly allied to quartz rock. Indeed, in respect to extensive tracts, it is often difficult to say whether it should be denominated quartz rock or mica slate. Sometimes it exhibits a double set of strata seams; one set being oblique to the other. It contains also not unfrequently beds or tuberculous masses of white or sometimes blood red quartz.

9. *Anthracitous Mica Slate.* This is simply a very fine grained mica slate, approximating to clay slate, which has been impregnated and rendered black and shining by carbon. I am disposed to regard the rock constituting the immediate roof and floor of the anthracite bed in Worcester, as belonging to this variety, although I am aware that it has been generally regarded as argillaceous slate. But I think that in all cases careful examination will detect the mica. Of this, however, more in another place. This variety occurs, also, in Ward and in Dudley. (Nos. 717 to 719.)

10. *Plumbaginous Mica Slate.* This rock differs from the last only in exhibiting the gray aspect of plumbago, rather than the dark color of anthracite. But probably in most cases very little plumbago is present. Yet the resemblance is often striking. This variety occurs frequently among the newer beds of mica slate; as for instance on the east side of Connecticut river in Southampton, Conway, Shelburne, &c. (Nos. 713 to 715 and 718 and 719.)

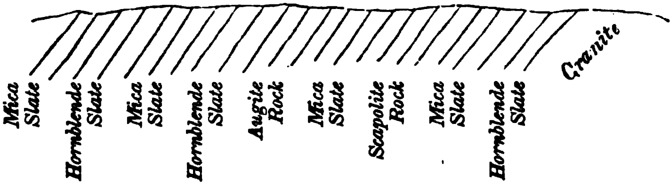
11. *Conglomerated Mica Slate.* In Haverhill and Amesbury I observed fragments of mica slate cemented by the hydrate of iron, so as to form a conglomerate. (No. 716.) It is, however, of very limited extent; occupying only occasional fissures in the rock, and is probably the result of slow disintegration, and the subsequent infiltration of iron from the decomposition of pyrites.

In the vicinity of the sienite in Whatley, I found a bowlder obviously composed of fragments of mica slate, which were once partially fused. They are cemented together chiefly by feldspar. The numerous nodules of the mica slate imbedded in the sienite at that place will render this explanation rational, as I shall attempt to show in describing sienite. (No. 724.)

12. *Indurated Mica Slate.* In the same region in Whatley, I found a bowlder between quartz and chert, of a dark gray color, exhibiting traces of an original slaty structure. (No. 725.) As

Dr. Macculloch says of a similar variety found in Scotland, 'it is not enumerated with siliceous schists, because it has not been the practice so to do ; but it bears a strong analogy to the primary varieties of these.' *

13. *Augite Rock.* It may not be expected to see this rock placed in this connection : since the rock of this name described by Dr. Macculloch in Europe, is an unstratified overlying rock, associated with basalt and greenstone. But the one here introduced, is of entirely a different character. It is ordinarily composed of granular and semi-crystalised augite, of a greenish or yellowish color, mixed with quartz in small quantity ; and is interstratified with mica slate and hornblende slate. And since it occurs in too small a quantity to be described as a distinct rock, I thought the proper course would be to notice it in this connection. (Nos. 726, 727.) I have found it only in Williamsburgh, two miles west of the meeting house, at the locality of smoky quartz and plumose mica ; where its characters correspond with those mentioned above. But Dr. Emmons informs me that it exists in Chester in the situation exhibited below : that is, there exists in that town such an alternation of strata. One of the beds of this rock is partly made up of 'a variety of *paratomous augite-spar,* which cleaves into thin plates and approaches nearly in some specimens to schiller spar.' 'Yet' says Dr. E. 'I should not call the stratum Diallage Rock.' (so it had been called) 'The loose bowlders which I first found were aggregates of this variety of pyroxene and feldspar. I afterwards found that they came from the mica slate and did not generally resemble granite.' Concerning the scapolite rock, placed by Dr. Emmons on the above section, he has given me no information.



Topography of Mica Slate.

It will be seen by the Map that this rock occupies several large tracts in the State. And it exists, also, in smaller quantities, associated in numerous places with gneiss and granite, but not shown on the Map. Thus the region in Northampton, Williamsburgh,

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* Classification of Rocks, p. 280.

Goshen, &c, colored as granite, is in fact nearly half mica slate. But it would be impossible to represent the true relative position of the two rocks; and, therefore, I have colored the whole space as composed of the predominant rock. And the same remarks will apply to almost every other range of granite that is represented in the central or western parts of the State.

The mica slate of Berkshire is chiefly of those varieties that approximate to argillaceous and talcose slate. It there forms lofty insulated mountain peaks, or continuous ranges. Saddle mountain, nearly 4000 feet high, and the highest point in the State, is composed of this rock. And so is the eastern part of Taconic range: as well as nearly all those broken ranges of mountains extending from Lenox through Stockbridge, Great Barrington, and Sheffield. As a general fact, the limestone occupies the vallies; and this would be deemed conclusive proof that this rock was deposited subsequently to the mica slate, did we not find it sometimes alternating with the slate. Shall we then infer, that the limestone being much more liable to disintegration than the slate, has been decomposed and abraded so as to bring it down to much the lowest level?

As we ascend Hoosic mountain, the mica slate assumes a much more crystalline aspect and appears to belong to the oldest varieties of this rock. It is essentially of the same character across the whole mountainous range between the vallies of Berkshire and the Connecticut: though as we approach the latter valley, we find it sometimes assuming an argillaceous or arenaceous character; and in Leyden it passes into distinct argillaceous slate.

It will be seen by the Map, that the Hoosic mountain range, (by which I mean all the mountainous region between the vallies of Berkshire and the Connecticut,) is composed mainly of two wedged shaped patches; the one of gneiss and the other of mica slate; the first having its acute angle towards the north, the other towards the south. And yet, according to the Map, which shows the direction of the strata, (Plate XVI.) the strata extend uninterruptedly across both the wedges. And such I believe to be the fact. It is my opinion that the mica slate and gneiss pass laterally into each other; that is, as we go north, the feldspar decreases in quantity until it disappears; and of course the rock is mica slate; and so *vice versa*. But the lateral passage of one rock into another is extremely difficult to prove; because, on account of the diluvium spread over the surface, we cannot trace a stratum with certainty for any considerable distance. Accordingly this is a subject rarely touched upon by geological writers. I recollect, indeed, but a single statement of any fact resembling this: Dr. Macculloch speaks of the beds of red sandstone in Sky, as 'changing their composition even according to the line of their prolongations:'* But they merely change from red sandstone into gray quartz rock; which might have resulted from the application of heat. Yet I see no insuperable difficulty in supposing that in one part of an extensive deposite, gneiss might have been produced, and mica slate in another; I mean in the same stratum. Some geologists suppose that these rocks were produced by direct crystallization from aqueous solution: and on this hypothesis, I can imagine how one portion of the menstrum might be destitute, or nearly so, of feldspar: while the other part should abound in it; especially if the supposed lake or ocean were shallow. Other geologists suppose these rocks to have been originally deposited in the condition of sediment, and that their crystallization resulted from their subsequent partial fusion by heat. And certainly in consistency with this hypothesis, may the change of composition under consideration be explained. But as to the fact of such a change in the present case, I would not wish to be very positive without farther examination. It is, however, certain, that much of the gneiss in the Hoosic range so much resembles mica slate, that Prof. Dewey was led to describe it as such. But as it does pass into distinct gneiss towards the south part of the State, and especially in Connecticut, I have not hesitated thus to mark the whole formation as far north as the rock contains any noticeable quantity of feldspar. I suspect that careful observation might discover that the rock contains feldspar across the whole State, and that the patch of gneiss represented in Whitingham, Vt. is a continuation of the range marked on the Map as extending only to Savoy.

Near the central part of this range of mica slate, occurs a range of talcose and chlorite slates, in conformable order, and passing insensibly into the mica slate. Hornblende slate and limestone are connected with it still more intimately, as the Map will show.

The mica slate on both sides of Connecticut river in Northfield, is separated from the range just described, by a deposite of argillaceous slate conformably stratified and gradually passing into the mica slate, though the direction of the strata of the clay slate is more towards northeast and southwest than that of the mica slate on the west: on the east, the mica slate becomes decided quartz rock; and this accompanies the mica slate, though often wanting, as far south at least as Leverett.

The narrow stratum of mica slate marked on the Map in the eastern part of Hampshire, and Hampden counties, is associated with talcose slate on one side, and with gneiss on the other. From having noticed occasional patches of mica slate among the gneiss as far north at least as Enfield, I have been induced to extend the stratum so far, in doubt, however, whether it be continuous over the whole distance. In many other parts of the broad gneiss range of Worcester county, I would here remark, we find limited beds of mica slate, apparently interstratified with the gneiss. But to exhibit all such cases on the Map would require immense labor, and be of little service.

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* Western Islands, Vol. I. p. 307.

In the northwestern part of the gneiss range of Worcester county, will be perceived on the Map, a succession of granite, gneiss, and mica slate deposits. I have not in that case attempted to give the exact extent of these several rocks in that region; but simply to indicate that such a succession of strata exists there; and that the different members of it occupy the surface in about the same ratio as the different colors. I apprehend that here is another example of a different composition in the same stratum prolonged. But I throw out this hint merely to excite others to make that thorough examination which I have not been able to do.

In passing eastward we next come to the Worcester range of mica slate, which has been several times referred to. This rock has heretofore been regarded, either as graywacke slate, or talcose slate, or both.* But after a careful examination of this formation in various places, from the mouth of the Merrimack to Connecticut line, I am constrained to regard it as one of the latest varieties of mica slate: probably what Humboldt would call transition mica slate. True, I have occasionally met with a limited portion of this rock, which had somewhat of a mechanical aspect; though not much more so than I have found in every range of mica slate which I have examined. In some cases too, there exists a glazing, apparently talcose, on the laminae of the rock; and this variety certainly approximates closely to graywacke slate. Still, these are not the predominant characters of the formation. Generally the rock is composed of gray arenaceous quartz, and mica in minute scales: the rock exhibiting too much of a crystalline structure for graywacke, and containing moreover, but little if any argillaceous matter. Where it contains considerable oxide of iron, as in the northeast part of Worcester, it presents at a little distance the dirty appearance of sandstone: but a closer examination will show the characters above pointed out. I saw not the least trace, moreover, of any organic remains in this formation; nor have I any evidence that such have ever been found. In short, though very probably genuine cabinet specimens of graywacke slate may be found in this formation, yet as a whole, I could not, without doing violence to my convictions, refer it to any formation, but mica slate. But as I shall place quite a number of specimens from this formation in the hands of the Government, others by inspecting them can form their own opinions as to their nature.

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* See Eaton's Canal Rocks and Geological Text Book.

I ought to remark that quartz very frequently predominates in this formation, and the mica almost disappears. Indeed, I am by no means sure that quartz is not the predominant ingredient in the whole formation: and if so, it ought to be denominated quartz rock. And it seems to me that there is much more reason to doubt as to this point, than whether it ought to be referred to graywacke, or talcose slate.

As we approach the east and west sides of this range, the characters of the mica slate become more decided; and in this slate of apparently greater antiquity, the veins and protruding masses of granite are more numerous; though they occur in every part of the formation, and sometimes in the argillaceous slate connected with it. Except in Worcester, Fitchburg, and Pelham, N. H. no attempt has been made to give the actual number and extent of these masses of granite on the Map; but simply to indicate where they are most numerous. I regard the frequency of the protrusion of this granite, and the perfection of its character, as some indication that the formation is older than graywacke. A large proportion of the most beautiful granite in the State is contained in this formation; and it is entirely wanting in hornblende; which circumstance if I mistake not, affords some presumption of its being among the oldest of the granites.

But does not the occurrence of anthracite in this formation at Worcester, decide at once that it cannot be mica slate? Some might, indeed, doubt whether that mineral is actually contained in the rock under consideration; because the slate forming the immediate roof and floor of the mine so much resembles clay slate. But the extent of this slate is quite limited, and then succeeds the rock under consideration; and I have already stated that I regard the slate in which the anthracite lies, as an anthracitous mica slate. I consider, therefore, the anthracite at Worcester as embraced in mica slate.

But can there be any doubt that anthracite does occur in mica slate and even in gneiss? The highest European authorities are, I believe, unanimous on this point. If we consult the *Tableau des Terrains* of Brongniart, we shall see anthracite marked in the stratum of gneiss that lies next to granite; also in his *Phylladique*, a variety of mica slate superior to the oldest variety of the graywacke series, &c. 'It has occurred,' says Dr. Macculloch, 'in gneiss, in micaceous schist, in primary limestone, and in a conglomerate rock said to belong to the primary rocks.'* 'It was believed for a long time,' says De Lafosse, 'that anthracite belonged exclusively to the primitive deposites. But it has been since found that it abounds in the secondary and transition formations,' &c.* 'Anthracite,' says Prevost, 'belongs almost exclusively to the oldest of the deposites called transition; where it is met with in beds or veins in the midst of mica slate, of gneiss, and of the *schistes-phyllades*, which overlie vegetable impressions of the family of ferns. For a long time, it is true, it was said that anthracite was found in primitive deposites; but it is probable that this term was applied to rocks and formations which are now placed in the transition formation. It seems almost certain that no primitive anthracite exists.'† I asserted in the first part of my Report that some of the anthracite in this country, viz. that at Worcester, occurs in primitive rocks, because it exists in mica slate. A reviewer says that 'he has certainly spoken unadvisedly when he asserts that it is so found in this country.'‡ But had he been aware that I reject the transition class, and consequently, following Macculloch, include every variety of mica slate and gneiss, the older varieties of quartz rock, and clay slate, in the primitive class, he would have seen that my statement was in perfect accordance with the authorities quoted above; and their correctness and high standing, I presume, he would not call in question. When Prevost asserts that 'no primitive anthracite exists,' he means none which he calls primitive. But in the same paragraph he says that this mineral does exist in mica slate and gneiss; every variety of which, geologists of no mean name regard as primitive. If this is all that is meant by the reviewer, there is between him and me no difference of opinion, except in the use of the word primitive.

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* System of Geology, Vol. II. p. 296.

If it be true, as I suppose, that the Worcester anthracite occurs in mica slate, we see the reason why it passes into plumbago, as I have elsewhere shown that it does. For whatever be the cause, as a general fact it is true, that the older the rock in which carbon is found, the more compact it is, and the nearer does it approximate to the semi-crystalized condition of plumbago.

On the first edition of the Map, a small patch of mica slate was represented in Sherburne. But its extent, as I observed it, was so limited that I have thought it best to omit it. I am not without suspicion, however, that this rock may be found of considerable extent, connected with granite, in Sherburne and in the towns north of that place, as far as Sudbury at least.

The narrow strip of mica slate in Smithfield, R. I., represented on the Map, associated with talcose slate, is of rather a peculiar character. It is decidedly arenaceous, and even resembles certain micaceous sandstones. (No. 675.)

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* Dictionnaire D'Histoire Naturelle, Art. Anthracite.

† Dict. D'Hist. Nat. Art. Houille.

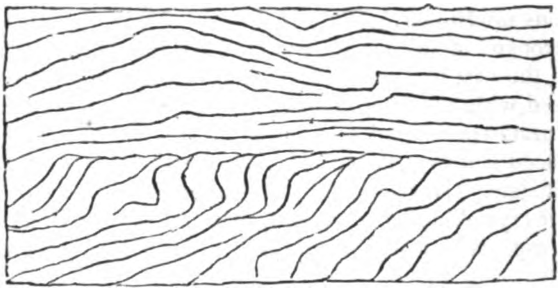
‡ Peter A. Browne, Esq.—Bucks county Intelligencer, Sept. 3, 1832.

The tongue of mica slate exibited on the Map, as extending through the east part of Andover into Middleton, is very probably connected with the Worcester range; since the direction and dip of the strata correspond with those of that range; and indeed I have traced it nearly to the place of connection with the Worcester mica slate. But commonly it is more decided in its characters, and more crystalline in its texture, than the rock of that range generally; especially where it approaches the coarse granite of Andover.

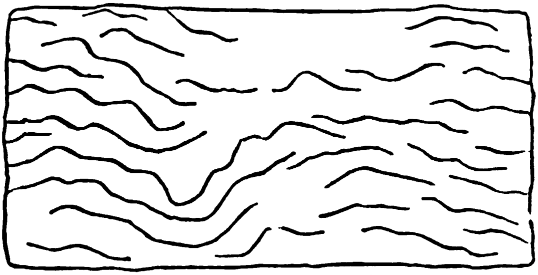
Slaty and Stratified Structure of the Mica Slate, with the Dip and Direction of the Strata.

It is rare to find even a small portion of this rock destitute of a schistose structure. But it is not uncommon to meet with extensive masses in which it is very difficult to trace any strata seams. In other places, however, no rock exhibits more regularity and beauty of stratification. Such differences may in general be explained by local disturbances; but sometimes no appearances will warrant such an explanation of the phenomena. And it seems reasonable to impute something to different proportions of the ingredients in the rock, and to peculiarities in the mode of formation. In general, the less the quantity of mica, the more regular is the stratification. The mica slate in Goshen, Chesterfield, &c., which is remarkably regular in this respect, consists, however, chiefly of mica. Those varieties exhibit most of contortion and undulation in the layers, which are of a plumbaginous aspect, and contain tuberculous masses of quartz.

Though our mica slate is sometimes divided by a double set of parallel fissures, yet I have never met with any examples in which the planes of stratification make an angle with the laminae of the slate. The flexures of the laminae, however, seem in a great measure to be independent of the planes of stratification; and the two structures appear to have resulted from different causes. The two following sketches will illustrate this. In each case a single stratum only is represented; and it will be seen that the curvatures of the laminae have no connection with the strata seams which are represented by the parallel lines that include the contorted layers. In these cases the strata are two or three feet thick; and they are generally thick; sometimes eight or ten feet, where the slate is much bent. The strata are often bent as well as the laminae, and sometimes the curvatures of the former are parallel to those of the latter.



Contortions in Mica Slate: Whately.



Contortions in Mica Slate: Conway.

The following extracts from my travelling notes, will show the dip and direction in numerous places of the strata of the different ranges of mica slate that have been described. It has already been mentioned that this rock, in connection with the limestone of Berkshire county, has a direction north and south, and a dip from 15° to 30° east, often greater. Between Cheshire and Lanesborough, for instance, its strata dip from 60° to 90° east; and between Lanesborough and Hancock, from 30° to 40° east.

Hoosic Mountain Range.

	Direction.	Dip.
Hoosic Mountain, western slope,	N. and S.	20° to 90° East.
Florada, east slope of do.	N. a little W.	70° to 90° East.
From Chester to Becket.	N. and S.	80° to 90° East.
Near Chester villiage,	E. and W.	46° North
Goshen, Plainfield, Hawley, Charlemont, and Zoar,	N. and S.	nearly 90° East.
Goshen, northwest part of the town,	E. and W.	25° North.
Westfield to Blanford,	N. and S.	70° to 90° West.
Chester, Worthington, (east part,) Chesterfiield, (west part,) Cummington, (east part,)	N. and S.	nearly 90° W.

Cummington, (west part,)	N. and S.	nearly 90° E.
Heath,	N. and S.	nearly 90° W.
Colraine,	N. and S.	nearly 90° E.
Whately,	N. several degrees E.	70° to 90° East.
Conway, Shelburne, Leyden, Buckland, and Ashfield,	N. and S.	20° to 70° East.
Leyden, (at the 'Glen,')	N. and S.	90°

It will be seen that the general direction of the strata in this range is north and south, and the dip very great; for the most part nearly vertical. The most remarkable exception is that which occurs in the northwest part of Goshen, where the strata run almost east and west and have a comparatively small dip. Although these strata are remarkably regular, yet I cannot but believe that this peculiarity has resulted from the protrusion of that vast mass of granite which lies a little east of the slate in that town, in Williamsburgh, Northampton, Whately, &c. I can easily conceive how a vast mass of slate, might be thrown into an anomalous position over a considerable extent of surface, without affecting the continuity of the planes of stratification in limited spaces.

In the Connecticut valley.

	Direction	Dip.
From Fitzwilliam to Richmond, (N. H.)	N. and S.	East.
From Richmond to Winchester, (N. H.)	N. and S.	30° to 40° West.
From Winchester to Northfield,	N. and S.	nearly 90° East.
In Northfield,	N. E. and S. W.	30° West.
Do. west side of the river,	N. and S.	20° to 60° East.

In this range are frequent alternations of gneiss and protruding masses of granite; and in the south part of New Hampshire there is a good deal of irregularity in the dip and direction of the strata. That region needs farther examination and elucidation.

Worcester and Merrimack Vallies.

	Direction.	Dip.
Webster,	N. and S.	45° West.
Ward,	N. and S.	70° to 80° West.
Worcester, west of hill of granite,	N. and S.	25° West.
Do. east of the same,	various,	25° to 90° Easterly.
From Worcester to Berlin,	N. E. and S. W.	20° to 90° N. W.?
Sterling,	N. several degrees E.	60° to 70° West.
(This last is the most usual dip of this range of mica slate.)		
Leominster,	N. several degrees E.	West, large.
Fitchburg to Lunenberg,	do.	10° to 30° Easterly.
Between Lunenberg and Shirley,	do.	Westerly, small.
Boxford,	N. E. and S. W.	25° to 50° N. W.

	Direction.	Dip.
Groton,	N. E. and S. W.	30° to 45° S. E.
Pepperell,	do.	nearly 90° N. W.
Townsend,	N. and S.	30° to 60° East.
Andover,	E. and W.	70° to 90° North.
Methuen, (Falls,)	E. and W.	20° to 30° North.
Tyngsborough to Dunstable,		Southeast.
Methuen to Dracut,		Northwest, large.
Lowell to Chelmsford,	nearly E. and W.	do.
Between Newburyport and Bradford,	do.	Northerly.

There would seem from the above statement, to be great irregularity in the direction and dip of the strata of this range. Yet it must be recollected, that I was careful to notice all the important anomalies in these respects, that fell under my observation; while I made few records where the usual dip and direction were observed. Hence the statement above made, in respect to the usual dip and direction, may be true, although not taught by the preceding table. And the same remarks are in a measure applicable to other rocks. To prevent any false inferences from such statements, I have drawn the Map (Plate XVI) which exhibits the predominant direction; and the sections appended, which exhibit the predominant dip, of the strata—anomalies being neglected, unless they are of considerable extent. In the range under consideration these inequalities are somewhat numerous. Yet I am inclined to the opinion that the mica slate along the western border of this range, is connected with that system of stratification which is exhibited by the great body of the gneiss in the western part of Worcester county, where the strata usually run north and south: while the great body of this range is connected with the system of stratification that prevails in the gneiss range, running northeast and southwest, in the east part of Worcester county, and the west part of Middlesex. South of Worcester the western margin of the gneiss lying east of the slate, runs nearly north and south; and hence the mica slate there affects the same direction, except in the vicinity of the anthracite bed; where it curves around the north end of the hill of granite, west of the mine. As we proceed northerly, the gneiss trends away more towards the northeast, and the mica slate conforms to it. Still farther to the northeast, the strata of the mica slate turn more easterly: because the longer axis of the valley of the Merrimack lies in that direction; and in this the slate seems to have been originally deposited.

These suggestions may explain some of the irregularities apparent in the stratification of this mica slate. And when we recollect, that numerous masses of granite are protruded through it—some of them of great extent, as at Fitchburg, for example—

I think we shall have no difficulty in explaining the remaining anomalies.

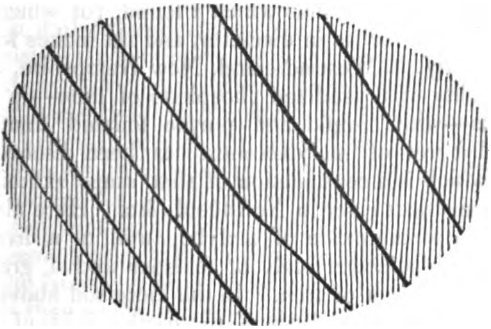
The strata of mica slate in Sherburne, run northwest and southeast, and dip northeast about 45°. This small deposit is very obviously connected with that system of strata which appears in the gneiss of the southeast part of Worcester county; as will be manifest when I come to describe that rock.

At Woonsocket Falls in Cumberland, R. I. a peculiar mica slate appears, running south several degrees west, and dipping southeast from 60° to 80°.

Veins in Mica Slate.

These consist chiefly of granite and quartz; but it will be more convenient to describe them when treating of granite.

Some of the more close grained and imperfectly schistose varieties of mica slate exhibit by disintegration, that kind of structure which has been sometimes denominated *veins of segregation:* that is, veins produced at the time of the formation of the rock, or when it was in a fluid state, by the play of chemical affinities, which in a measure separated the ingredients into different masses; so that when atmospheric agencies wear away the rock, the harder parts remain in relief on the surface, like genuine veins. The following is a sketch of a bowlder of mica slate, not more than two feet in diameter, which exhibits a double set of these segregated ridges, the smaller ones amounting to fifty five, and the larger ones not being parallel to one another. I did not notice the direction of the slaty laminæ in this bowlder, but probably it coincides with that of the most numerous ridges.



Veins of Segregation in Mica Slate: Chesterfield.

Mineral Contents.

More simple minerals occur in this rock than in any other, with the exception perhaps of granite.

To begin with the earthy salts: it is hardly needful to mention one so common as calcareous spar, which always occurs more or less in connection with limestone. It is in distinct crystals sometimes, also, in the mica slate; as at Chester, where several of its secondary forms have been noticed. The laminated variety occurs in connection with the micaceous limestone in Whately, Conway, &c.

The sulphate of alumina and potassa, or native alum, is not unfrequently found efflorescing upon mica slate; resulting from the decomposition of the sulphuret of iron and probably also of feldspar, as this is the most probable source from whence it derives the potassa. In Sheffield it is said that 'pounds of it can easily be collected in as nearly a pure state as that of commerce.'* The localities mentioned in the first part of my Report, in Leominster and Barre, I am satisfied ought to be referred to the gneiss formation; although in hand specimens, the rock in which the alum occurs can hardly be distinguished from mica slate.

The phosphate of lime has been noticed in Williamsburgh, Chesterfield, Chester, Middlefield, Norwich, Hinsdale, &c. That in Williamsburgh is in hexagonal delicately green crystals, and is doubtless apatite. That in Chesterfield is associated with sappare; as may be seen on No. 750, and almost exactly resembles the chrysoberyl of Haddam; but the ease with which it is impressed by steel, shows its nature at once. In Norwich this mineral occurs in a gray quartz and black mica, and in the vicinity of granite. One of the imperfect crystals which I found, (of which No. 728 is part,) was three inches in diameter, and six inches long.

Quite recently, in Westmoreland, New Hampshire, a very interesting locality of crystalized phosphate of lime—in 6 and 12 sided prisms—with limpid and purple foliated fluate of lime and fine sulphuret of molybdenum, has been discovered in the mica slate, which is a continuation of that range exhibited on the Map on Connecticut river in Northfield, &c. Here also we find an incrustation of the oxide of molybdenum, of a lively yellow color as well as distinct crystals of feldspar and a great deal of disseminated sulphuret of iron. In the loose soil above the rock, there exists likewise not a little of the earthy oxide of manganese. All these minerals occur together in the northwest part of the town on the farm of a Mr. Lincoln. A better locality of fluate of lime exists two or three miles east of his farm. The quantity of molybdenum at Mr. Lincoln's locality is much greater than I have ever seen or read of.

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* Robinson's Cat. of American Minerals, p. 69.

Fluate of lime exists in small quantity in the mica slate in Conway; and a green variety was found a few years since in the same rock in Putney, Vt.

Almost every variety of quartz described in the books, occurs in our mica slate. It is hardly necessary to mention crystalized quartz, which is found almost everywhere, and in nearly every rock. The white hyaline quartz, passing into white milky quartz, exists in large beds, or tuberculous masses, in almost every part of the mica slate. It is an interesting fact, that a large proportion of this quartz is fetid in the Hoosic mountain range. I have observed this variety on that range from the south part of Connecticut, to the south part of Vermont, over an interval of more than 100 miles. Sometimes this hyaline quartz—as in Shelburne and Colraine—is tinged of a blood red color, and sometimes of a wine yellow, by iron. As the mica slate approaches to clay slate, the quartz becomes bluish and greasy in its fracture. Sometimes, also, it is pavoine or irised, as in Fitchburg, Leyden, &c. It is found, also, of a rose red color, in Williamsburg, Chesterfield, Blanford, and Chelmsford. I am not certain that at the two latter places mica slate is its gangue, because I found it only in bowlders: yet I have little doubt that such is the fact. That in Blanford appears to be the finest; and probably if some pains and expense were devoted to getting it out, rich specimens might be procured.

In the mica slate in the southeast part of Conway, a vein of quartz, six or eight feet thick, and nearly perpendicular to the horizon, runs N. 20° east. It is the gangue of two ores, the red oxide of iron and the gray oxide of manganese: which, however, do not occur in it abundantly at the surface. But they have imparted a great variety of colors to nearly the whole gangue; and rendered a part of it very compact. Hence we find there brown and yellow jasper, and sometimes chalcedony. The various colors, black, white, red, yellow, and brown, are often intermixed, sometimes irregularly, forming breccia agates; and rarely in parallel stripes, forming a banded agate. Some of these, if polished, would form I doubt not elegant ornaments. (Nos. 738 to 748.)

At the same place we find a delicate variety of tabular quartz, in which the laminæ are as distinct and thin as the folia of feldspar. Sometimes they are so arranged as to present the appearance of pseudomorphous crystals; and sometimes they so intersect as to form cells. In the cavities of the compact quartz, there sometimes occur minute crystals of quartz, giving the geodes a rich appearance. (Nos. 746, 747.)

About one mile northeast of the College in Amherst, I have recently found numereus bowlders almost exactly resembling those in Conway just described. Chalcedony and hornstone, however, occur here rather more commonly. I cannot doubt but these masses were brought to that spot from the mica slate which occurs a few miles north, both in Amherst and Leverett. The delicate greenish hornstone, found by Mr. Shepard in Amherst and Pelham, some years since, undoubtedly had the same origin. I do not despair of discovering the parent vein.

Some of the quartz of these bowlders is yellow and in small crystals. Yellow and irised quartz also occurs in mica slate in Fitchburg. Jasper is found on the banks of Deerfield and Westfield rivers in rolled masses, and probably originated in mica slate.

The gangue of the lead, zinc and copper ores in Hampshire county, is chiefly crystalized and radiated quartz: and these veins sometimes occur in mica slate: but as they generally traverse granite, I shall describe them in treating of that rock.

Not having visited the beds of manganese and iron marked on the Map in Hinsdale and Winchester, New Hampshire, I am not sure that they occur in mica slate, though strongly suspicious that such is the fact. In the first part of this Report, I have stated all the facts with which I am acquainted respecting these beds; except that I have since ascertained that nearly all of the manganese ore is the ferro-silicate, or Fowlerite. (No. 1027.)

The best locality of fibrolite that has been discovered in this slate, is in Lancaster, near the village. It is found in a bowlder. The fibrous structure of this mineral is sometimes almost changed into the foliated. The masses are from an inch to three or four inches long, and half an inch broad. It has been met with, also, in some other places in the State.

Under argillaceous slate, I have noticed the occurrence of beautiful amianthus and bucholzite in the slaty rock that embraces the anthracite in Worcester. If my opinion be correct, in referring that rock to mica slate, these minerals should be described in this connection.

The localities of sappare are numerous. The best is Chesterfield; from whence large quantities have been obtained; some of it finely crystalized and of a rich color. Its colors vary from nearly white, to dark blue. It is not possible at present to obtain specimens as fine as No. 750. It is found also in Blanford, Worthington, Middlefield, Deerfield, &c. The Rhoetizite is found in Blanford and Russell, according to Dr. Emmons. In Canton, Ct., sappare occurs crystalized and of a green color.

Of the situation of staurotide in Massachusetts, I have given a general account in describing the staurodiferous mica slate. Chesterfield perhaps, near the locality of green and red tourmalines, is as good a spot for procuring specimens as any one in Massachusetts. But no specimens found in this State equal those from the western part of New Hampshire.

Dr. Emmons states in his Mineralogy, that pinite is found in Chester: though he does not mention the rock in which it occurs. I mention it here merely because mica slate is the predominant rock in Chester.

If andalusite and macle are the same species, then the most abundant locality in Massachusetts is in Lancaster, in clay slate. But the mineral which has been generally called andalusite, is most abundant in Westford, in mica slate. And I am happy to state that numerous specimens can be obtained from thence. It occurs in the stone walls, from a hundred rods to a mile east of the centre of the village, and may sometimes be found in distinct prisms, greatly resembling specimens from Germany. It is of a reddish color, and sometimes the masses are two or three inches across. Generally they are accompanied by a fibrous mineral, resembing talc: but I am not satisfied as to its nature.

Schorl is not common in mica slate. But in Norwich I found a curved specimen of this rock, nearly a foot square, entirely covered with prisms of this mineral, of the size of a goose quill, and generally acuminated. The specimen was weathered so as to leave the schorl in bold relief.

Scapolite is found at Chester, as already mentioned; and Dr. Emmons in his Mineralogy says that it exists 'in veins in mica slate, associated with hornblende, pyroxene, and garnet; but the crystalization is generally confused and indistinct.' It is unnecessary to refer again to other localities of hornblende and pyroxene as connected with mica slate; except to say, that Dr. Emmons mentions 'Middlefield, Chester, Hinsdale, and most of the mountain towns in New England,' as containing sahlite and coccolite.

Garnet is more widely disseminated in mica slate than any other mineral. It differs in size from an almost microscopic grain, to a crystal of two inches in diameter; and its colors are generally reddish, but sometimes black, even approaching very nearly to melanite. In the slate containing the sappare at Chesterfield, the reddish garnets are very numerous and sometimes quite large. In the amphibolic aggregates, the garnets are usually black. In Plainfield, Dr. Porter has found garnets disseminated in quartz. Garnet and staurotide are usually associated; as at Chesterfield, Middlefield, and Chester. The usual form of the crystal is a rhombic dodecahedron, which is sometimes truncated on its edges.

The mica slate formation in Williamsburg, Middlefield, Chester, Hinsdale, Cummington, Worthington, Plainfield, &c., frequently contains crystals of epidote. Generally they are imbedded in quartz, and frequently associated with hornblende and augite. Zoisite, now regarded by able mineralogists as a species distinct from epidote, occurs also in Goshen, Hawley, Middlefield, Chester, Hinsdale, Chesterfield, Conway, Windsor, and particularly in the north part of Leyden, in large quanties. Indeed, it may be found scattered over nearly every part of the Hoosic mountain range of mica slate; and on the same range as far northward into Vermont as I have examined.

In the stone walls, fifty rods west of the residence of Gov. Lincoln in Worcester, several specimens of Idocrase were found a few years ago, associated with massive garnet and pyroxene. It was crystalized in right rectangular prisms, truncated on the lateral edges so as to produce eight sided prisms. There can be little doubt that the rock containing this mineral, belonged originally to the mica slate range of Worcester valley. It appears from Beudant's work on mineralogy, that it exists in mica slate in Europe, although generally of volcanic orign. As the Worcester locality is now exhausted, I am indebted to William Lincoln, Esq. for the specimen, No. 765, in the collection. According to Dr. Emmons the same mineral occurs in Chester.

The latter gentlemen has also found stilbite, heulandite, analcime, and chabasie, with hexahedral calcarous spar, on mica slate in the same town. I am not aware that these minerals (except the last,) have before been found in this rock; although stilbite occurs in the Alps in granite rocks. But the others are confined almost exclusively to trap rocks and metalliferous veins.

The mineral called anthophyllite, which some able mineralogists yet consider as a doubtful species, is found in many places in the Hoosic Mountain range of mica slate. It occurs in fibrous masses, or imperfect prisms, imbedded in the mica slate. In Chesterfield it is associated with sappare and garnets. In Chester it is connected with pyroxene, garnet, and staurotide. It is found also in Blanford in abundance.

The mineral called Cummingtonite from its locality, (Cummington,) is thought by some mineralogists to be a variety of anthophyllite. Prof. Dewey, however, who first described it, regarded it as a variety of epidote. It needs farther examination. It is found in several places in Cummington, and also in some of the neighboring towns. I have found it likewise in Warwick, on the east side of Connecticut river. Dr. Thomson is decidedly of opinion that this mineral belongs to a new species allied to the karpholite.

It is not uncommon to find a small quantity of sulphur upon the mica slate in a pulverulent state, and proceeding from the decomposition of some sulphuret. But there is no place where it is found in sufficient quantity to be named.

The anthracite and graphite which I consider as connected with mica slate in Worcester, I have already described. Graphite also occurs in mica slate, west of Connecticut river: as at Cummington, Chester, Worthington, &c. But I know of no interesting localities. The magnetic oxide of iron exists in the same mica slate range, in disseminated octahedra: as in Blanford, Chester, &c. Sulphuret of iron is met with likewise in the same situation. In Heath, some very handsome specimens of cubic crystals have been found. In Hawley, it occurs massive in considerable quantity, near the junction of the mica and talcose slate.

On the top of a mountain in Canaan, Ct. there was found, twenty years ago, a small mass of native iron. The mountain is composed of mica slate. Several years ago I visited the spot and was led to the conclusion, that probably a large mass of this mineral might exist there, from the irregular action of the magnetic needle in the vicinity. A full description of the spot was given by me in the 14th volume of the American Journal of Science. In the 20th volume of the same work, it has been suggested by Mr. Shepard, that the recent discoveries in regard to the magnetic polarity of rocks and mountains, even of those apparently destitute of iron, will explain the facts which I observed on the Canaan mountain, without supposing a mass of iron within it. But if I understand this polarity of a mountain, it affects the needle more or less on every part of its surface: whereas it was affected on the Canaan Mountain only within the space of a few square rods of level ground near the top; although I judged that the whole top embraced hundreds of acres. Hence I infer that we must suppose some local cause acting there on the needle. And why may not this be native iron, since it was near that spot where veritable native iron was knocked off from a bowlder? If this be a reasonable supposition, it would certainly be very interesting to have it confirmed; since native iron, (except the meteoric,) is one of the rarest of minerals.

One mile north of the village of Worcester, an excavation was made several years ago in the mica slate in search of silver, &c. as already described in the first part of my Report. It is impossible to ascertain at present how wide is the vein that was explored: but the minerals thrown out, and lying around the opening, are arsenical pyrites, carbonate of iron and galena. Sometimes the arsenical iron is in distinct crystals in quartz; but I could not ascertain their form. A little west of the village of Worcester, these same minerals occur in the stone walls, along with the idocrase, rendering it probable that this last mineral originated from that metallic vein.

In Sterling, one and a half mile southeast from the village, are two excavations in the same mica slate as that at Worcester: and large quantities of similar ores have been thrown out. Carbonate of iron is most abundant; arsenical iron less common. Blende, of a cherry red color, is found there in considerable quantity; galena also occurs, which is argentiferous, according to Dr. C. T. Jackson. Sulphuret of iron exists in connection with the ores that have been mentioned, and pyritous copper also, with the carbonate of iron. Before the compound blowpipe the blende was reduced, and burnt with the flame peculiar to zinc, throwing off the white oxide. Numerous quartz veins traverse the carbonate of iron, and a considerable quantity of red oxide of iron occurs in the quartz, probably proceeding from the decomposition of the carbonate. The lamellæ of this carbonate at Sterling, as well as at Worcester, are very much curved and commonly reddish white. These ores at Sterling constitute beds in mica slate, whose direction is several degrees east of north, corresponding to the general direction of the range. The dip at the mines is 60° to 70° west.

The above ores need a careful analysis: for it is well known that in other places they sometimes contain a considerable proportion of silver and gold.

The micaceous oxide of iron described in the first part of the Report as in Montague, is in veins traversing mica slate and granite, chiefly the former. But I have nothing to add to the description which I have given of these veins.

Sulphate of iron is not uncommon in small quantities on the mica slate of this State.

The only remaining mineral to be noticed in the mica slate of Massachusetts, is the red oxide of titanium. It is very common along the eastern margin of the Hoosic mountain range of mica slate; occurring in four or eight sided prisms, generally striated and often geniculated. It is usual to find it associated with zoisite, as at Leyden, where numerous specimens have been found. Sometimes it penetrates quartz, and sometimes is connected with hornblende. In Shelburne I found it in distinct crystals in the mica slate, without any other mineral. I have found it likewise in Colerain and in Conway. At the latter place I found one or two geniculated prisms, more than an inch thick; also in small crystals having the primary form, that is a right square prism. It is found also in Williamsburg, Chesterfield, Middlefield, &c. In Chesterfield I found a small quantity of what I take to be the titanite, or ferruginous oxide.

Specimens of the greater part of the minerals that have been described above will be found in the collection which is placed in the hands of the government. To procure every one of those, which have been described as occurring in the State, if not impossible, would require so much of time and expense, that I have not felt authorized to attempt it without special directions.

Theoretical Considerations.

The prevailing opinion among geologists until recently has been that mica slate and all the older primary rocks have been deposited from a chemical solution of their materials in water. But this opinion appears to labor under insuperable difficulties. It seems to me to be opposed by the semi-mechanical character which some of these rocks exhibit. But waving this difficulty, it is impossible to conceive how the materials of all these rocks could have been held in solution by all the waters on and in the globe; since the earths that form them are scarcely soluble at all in water. Yet even allowing such a solution possible, by what unheard of chemistry was it, that so many distinct minerals as enter into the composition of these rocks, or occur disseminated in them, should have been crystalized at the same instant? The supposition is opposed by all that we know of the crystalization of different substances in the laboratory in the same solvent. For they crystalize in succession, not simultaneously. But we know that the melted matter of a furnace, if slowly cooled, will separate into different compounds,* and the same result takes place in fused basalts, and in the lava of existing volcanoes. Surely then, it seems to me that nature and art both teach us that analogous cases of crystalization in the rocks must have resulted from igneous fusion. But on the other hand, the foliated structure of the stratified primary rocks, proves that water must have been concerned in their formation; and that they could never have been in a state of complete fusion. I am inclined, therefore, to the theory which supposes that they were originally mechanically deposited from water, like the existing secondary and tertiary rocks, and that they have subsequently been subjected to such a degree of heat as enabled their materials to enter into a crystalline arrangement, without destroying their structure. That the two things are compatible, seems probable from the change of bulk produced on solid bodies by slight changes of temperature, showing a motion among the particles; from the changes of crystalization that sometimes takes place in solid glass; from the columnar structure assumed by certain sandstones when in contact with trap rocks; and from the experiments of Dr. Macculloch, who 'proved that every metal can completely change its crystalline arrangement while solid, and many of them at very low temperatures.'* This theory also explains why it is that the primary and transition rocks become less and less crystalline the higher we ascend in the series: for the higher they are, the farther they lie from the source of heat. This theory, however, does not suppose that all cases of crystalline structure in rocks has been the result of fusion: for limestone and quartz rock might have been deposited from aqueous solution. But if we suppose the source of heat to be in the interior of the earth, it must have operated more or less on every layer in the earth's crust; and, therefore, if this theory be true, probably all the older rocks have been more or less modified by heat. That the crust of the globe have been subject to the action of powerful and long continued heat, it seems to me no one acquainted with geology in its present state can doubt.

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* In a recent visit to the Dyottville Glass Manufactory in Philadelphia, (May, 1834,) I obtained specimens beautifully illustrative of this fact. They consisted of a green transparent glass, which contained distinct prismatic crystals: some of them more than an inch long, and nearly white. They are as hard as glass, and have a lamellar somewhat pearly aspect; but their nature I have not determined. The agent informed me, that they were always produced when the residuary matter in the furnace was slowly cooled. They finely illustrate the mode in which simple minerals might have been produced in rocks.

According to the theory just described, (I have not space fully to defend and illustrate it, but Dr. Macculloch has done it in his System of Geology,) argillaceous slate is nothing but shale, which has been subjected to heat, and perhaps increased pressure: quartz rock may have resulted entirely from aqueous deposition; or it may have been subsequently indurated by heat. Between mica slate and micaceous sandstone, there is a most striking analogy: indeed, it is no easy matter to distinguish by the eye between the specimen of sandstone, No. 177. from Northampton, near a mass of trap, and several specimens of mica slate. The same is true of the micaceous sandstones near Turner's falls, which are also in the vicinity of trap. The supposed origin of the other stratified primary rocks, I shall point out in treating of them.

As to the elevation and dislocation of the strata of rocks, particularly the primary, I shall say more in another place. But the manner in which the numerous flexures and contortions which their laminæ present were produced, deserves consideration in this connection; for these are more common in our mica slate than in any other rock; not even excepting gneiss.

These curvatures may have been produced before or subsequent to the consolidation of the rock. I have already pointed out the striking resemblance between the slightly undulating surface of some of the shales in the new red sandstone, and the gentle ridges and depressions at the bottom of almost every large river and pond, or on the margin of the ocean. And if argillaceous and mica slate had that origin which is supposed by the preceding theory, the analogous irregularities, so frequent on the surface of argillaceous and mica slate, may be referred to the same cause as that which produced them on the shale.

By comparing the sections which I have given of flexures in the newest tertiary formation, with those in our mica slate, it will be seen that the latter might have had their origin in the former, if we admit the theory that has been advanced of the origin of mica slate. It may be difficult, indeed, to account for these flexures in the clay: but that they were produced by some mechanical force, and not by igneous agency, I think it most manifest. And it seems to me, that a power which is adequate to the production of the cases which I have described, is sufficient to account for a large proportion of the minor flexures and contortions existing in clay slate, and mica slate; although I am not aware that but few examples similar to those which I have described, exist on the records of geology.

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* System of Geology, Vol. I. p. 190.

So much for flexures and contortions previous to the consolidation of the rocks. But these causes will not explain all the cases that occur. Sometimes we find alternating layers of quartz in the bent laminæ; and it would seem that the rock must have been soft, when such flexures took place. If we suppose the existence of a considerable degree of plasticity in the layers, mere gravity (if the laminæ were in an inclined position,) would have produced flexures in them. In other cases the force which elevated the strata might have operated unequally and produced a similar result; though as I shall attempt to show hereafter, there is reason to believe that this force sometimes acted laterally rather than from the interior of the earth. And some flexures and contortions are explicable only by supposing such lateral pressure.

Some facts lead us to suppose that mere moisture operates powerfully, deep in the earth, to render the strata flexible. Some limestones and sandstones exhibit this flexibility; and even granite in some deep quarries, is easily impressible. Hence the requisite plasticity may have resulted in many cases from water. But if the primary stratified rocks have been partially fused, we have another source from which this plastic state might have resulted.

11. TALCOSE SLATE.

I shall include in this formation the three rocks represented on the Map under the names of talcose slate, chlorite slate, and steatite. My principal reason for adopting this arrangement, is, that in the works of some of the ablest mineralogists, talc, chlorite, and steatite, are but varieties of the same species: and when mineralogists are not agreed that minerals are specifically distinct from one another, it seems to me improper for geologists to regard those minerals as sufficiently characteristic of different rocks, unless such rocks are widely diverse in their relative situation and structure. But in the district under consideration, it happens that the rocks mentioned above, are, for the most part, obviously members of the same formation, using this term too in a very limited sense.

Dr. Macculloch describes talcose slate as differing from mica slate only in the substitution of talc for mica : that is, it consists essentially of quartz and talc. It is this variety that constitutes the principal portion of talcose slate in Massachusetts. But other varieties are found, as the following description will show.

Mineralogical Characters.

1. *Schistose Talc.* This variety is more or less distinctly foliated and varies in color from blackish green to very light green, or greenish white. (Nos. 789 to 793.) It is the least abundant of any of the varieties.

2. *Steatite.* This is obviously only a scaly and semi-granular or partially indurated variety of talc. 'We see,' says Beudant, 'by these analyses, (which he had just quoted,) that the steatites differ from talc only by the presence of water. These substances also occur together and in precisely the same geological position. They appear even to mix in all proportions, and in some suits of specimens, there seems to be a passage from one substance to the other.'* These remarks correspond exactly with the steatite of Massachusetts ; although we have some beds of steatite which are associated with but a small quantity of foliated talc. But in general, these beds constitute a part of the talcose slate formation.

The color of this variety is usually light gray. In some quarries however, (as in Rowe and Zoar,) it is a delicate green ; and in such cases the rock is obviously nothing but foliated talc, which is so compact that it forms a fine stone for economical purposes. In the quarries the green and the gray varietes alternate ; although there is no seam between them ; and perfectly sound blocks may be obtained, which are partly gray and partly green. (Nos. 794 to 805.)

3. *Chlorite Slate.* Sometimes this variety is foliated and of a dark green color ; and in such cases I know of no means of distinguishing it from talc, except perhaps by its darker color. Generally it is slaty in this region, and very minutely scaly. In this case it probably owes its slaty structure to a small proportion of quartz which it contains. But the chlorite slate of the Hoosic mountain range is remarkably pure ; and I may add, remarkably regular and continuous in its slaty structure. (Nos. 806 to 816.)

4. *Quartz and Talc.* In this variety the talc is usually scaly, and the quartz arenaceous. Sometimes, however, the latter is

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* Mineralogie, Tome II, p. 212.

coarsely granular, or hyaline. When the talc predominates, and the quartz is in minute grains, they form the whetstone slate. (Nos. 817 to 825.

In Smithfield, Rhode Island, this rock is extensively quarried for whetstones. I learn from Dr. Webb, that the number annually quarried at this place and sent away, can hardly be less than 5000 dozen. Indeed, so important has this manufactory become, that the General Assembly of Rhode Island have passed an act to regulate the inspection and sale of the whetstones. It is not true, as stated by Mr. Eaton, that all our whetstone quarries are in talcose slate: for those in Norwich and Enfield are in decided mica slate.

This rock is employed, also, as a substitute for fire bricks in the lining of furnaces.

5. *Quartz, Talc, and Mica.* This variety may be considered either as mica slate, which takes into its composition more or less of talc, or as talcose slate, containing mica. Probably but little of our talcose slate can be found, that does not embrace a small proportion of mica; but talc and mica often resemble each other so exceedingly, that it is very difficult to say whether the rock is talcose or mica slate. I have felt this difficulty most in relation to a considerable part of the slaty rock in Berkshire county. And although I have there marked no talcose slate, yet I hardly expect that all geologists will follow my example. (Nos. 826 to 831.)

The fourth and fifth varieties constitute the greater part of the talcose slate formation.

6. *Talc and Carbonate of Lime.* Sometimes talcose slate lies next to limestone, as in Whitingham, Vt., and near the junction of the two minerals, they are mixed together. But the variety is hardly worth naming. (No. 832.)

7. *Talc, Quartz, and Carbonate of Iron.* It might be more proper, perhaps, to describe the carbonate of iron as disseminated through the talcose slate; though the iron most commonly occurs in the variety, No. 4. And this mineral, by its decomposition, imparts a character to this rock which will be noticed every where. It abounds in spots of the color of iron rust, and this is particularly the case where masses of quartz exist of considerable size. If I mistake not, it is in this decomposed carbonate of iron, that native gold occurs. (Nos. 833, 834.)

8. *Talc, Quartz, and Hornblende.* The latter mineral is in distinct though imperfect crystals scattered through the rock; but it occurs in such quantity, and over so great an extent of country, that it seems proper to make this a distinct variety. It is found along the eastern margin of the talcose slate formation, near its junction with the mica slate in Hawley and Plainfield: and it sometimes passes into distinct hornblende slate. (Nos. 835 to 839.)

9. *Talc, Feldspar, and Quartz.* This variety is intermediate between talcose slate and gneiss; and differs from the latter rock only by the substitution of talc for mica. It is obviously, however, a rock more mechanical in its character than gneiss; the feldspar existing in coarse grains. This description applies particularly to this rock in Smithfield, R. I. (No. 840.) But in Hawley the feldspar is scattered in crystalline masses through the rock, forming a distinct porphyritic talcose slate; (No. 841,) and it is almost destitute of stratification.

Topography of the Talcose Slate.

The principal deposit of this rock in Massachusetts, is in the midst of the mica slate of the Hoosic mountain range. It occupies a very elevated portion of that range, and is there obviously one of the oldest of the stratified rocks. I have traced this rock 20 or 30 miles into Vermont, where it is associated with limestone and gneiss on the eastern slope of the Green Mountains; and probably it extends much farther north. In Massachusetts it is most perfectly developed in its characters in Hawley and Plainfield; where it is several miles wide. Proceeding southerly this formation becomes narrower, and at length appears to terminate near the southern part of Becket; at least I have not observed it farther south, and between Chester and Becket it is only a few rods wide, alternating with mica slate and hornblende slate. The chlorite slate forms a narrow stratum along the western margin of the talcose slate, and I have not observed it quite as far south as the talcose slate. But northerly I have traced it as far as Whitingham, Vt., although I have not seen it in every place where I have crossed the Hoosic range. But being a remarkably distinct stratum, I have little doubt that it does extend as far, at least, as it is represented on the Map, and that it is continuous; since it is so narrow that it might in many places easily be hidden by diluvium.

I can have but little doubt that this stratum of talcose slate, like the mica slate with which it is associated, passes laterally into hornblende slate and gneiss: but I have nothing further to add to the remarks already made on this subject.

Several beds of steatite are connected with this range of talcose slate: viz. one in Marlborough, Vt.; one in Rowe; one in Zoar; one in Windsor; one in Middlefield,* and farther south, nearly on the line of the strata prolonged, we find a bed in Blanford, and at least two in Granville. The bed of this rock in Hinsdale, that in Cheshire, and that in Savoy, I have not visited; but as the gneiss and mica slate of that region frequently pass into talcose slate, not improbably they are connected with this rock. The bed in the northwest part of Windsor, however, I know from examination to be in gneiss; and perhaps those just mentioned are in the same rock. In Zoar we find mica slate, talcose slate, steatite, and serpentine, interstratified. The most easterly bed in Windsor appears to be embraced in the chlorite slate. That in Middlefield has talcose slate on the east side and hornblende slate on the west. That in Blanford, one and a half mile southwest of the meeting house, is in mica slate; but on one side a huge vein of granite lies in contact with the steatite. The bed in Smithfield, R. I., is in talcose slate.

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* I have just been informed that another bed of steatite has been opened in Middlefield, half a mile south of that noticed in the text; and that it is selling at a high price. The specimen sent me is certainly of a very superior quality, finer, I think, than any I have met with in Massachusetts. (June, 1834.)

With respect to the narrow stratum of talcose slate marked on the Map in the southeast part of Hampden county, and passing through Stafford, Ct., Monson, &c. I feel quite ignorant. I have satisfied myself only that it lies between the mica slate and the gneiss. The specimens will show that it produces a good lining for furnaces. To this formation I refer the steatite in Somers, Ct., although I have not visited the quarry.

Since the publication of the first edition of this Report, I have received from Mr. A. B. Chapin, of Wallingford, Ct., an account of the position and mineral contents of the steatite in Somers, as well as important additional facts relating to other rocks in that vicinity, which will be given in the proper place, and for which I am much obliged to that gentleman.

'The talcose slate,' (steatite of Somers,) says he, 'forms an isolated peak, rising to a considerable height above the surrounding country, dipping from 20° to 25° to the northwest, and terminating abruptly at the southeast end.

The edges of the strata crop out at this end about half way down the mountain, where it is covered by soil. Before arriving at the foot of the hill, a dike of trap stretches along nearly perpendicular to the line of dip, rising a few feet above the ground.

It is not only evident that the talcose slate' (steatite) 'rests on trap, but also probable that granite rests on the slate. Granite or gneiss appear on the surface in every direction from the talcose slate.'

The steatite beds marked in Shutesbury, Wendell, and New Salem, are surrounded by gneiss of the most decided character. That in New Salem contains serpentine, also, of a black color. The bed of serpentine, exhibited in Pelham, is a mixture of serpentine and talc; and is marked as serpentine, only because that mineral predominates. It forms a bed in gneiss.

On the 666th page of the first edition of this Report, a bed of steatite, just discovered, was noticed, as occurring in Worcester. I have not visited it; but it is found in the southeast part of the town; and I have reason to believe in gneiss. The proprietors informed me, that as yet they have explored the bed only about five feet in depth. The specimens (Nos. 403 and 1548,) show that this is the most beautiful steatite yet discovered in the State; and should the bed prove to be a large one, its proximity to the Blackstone Canal will render it of high value.

The bed of steatite in Groton occurs in the Worcester range of mica slate. But its situation and extent have been described in the first part of my Report.

In Cumberland and Smithfield, Rhode Island, two strips of talcose slate are shown on the Map, separated by a range of granite. I am not sure that the granite will be found extending uninterruptedly through these towns, as it is represented on the Map. But in crossing that region, I have always found one or two large beds of granite or sienite; and probably these rocks exist there in several beds in the talcose slate and mica slate. Yet this alternation could not conveniently be shown on the Map.

On the west side of the granite in Smithfield we find a peculiar kind of mica slate, (No. 675,) and a talcose slate, which has been already described as a whetstone slate. The extent of surface occupied by this variety—which is well characterised talcose slate—I am unable definitely to state; though it cannot be but a few miles in any direction, unless it be towards the southwest.

In the east part of Smithfield, and on the east side of the granite range or bed, the slate is often distinctly talcose; especially in the vicinity of the soapstone quarry, near the village called Maysville. But as we cross the strata towards the southeast, the characters become very obscure and perplexing. In one place the rock can hardly be distinguished from argillaceous slate; in another it greatly resembles graywacke slate; in another it is distinct chlorite slate; and in another it becomes hornblende slate. Epidote too forms an ingredient in a large proportion of the rock. In short, this series of slaty rocks is one of the most perplexing with which the geologist meets. It extends over nearly the whole of Cumberland, where it is interstratified with quartz rock, and is succeeded on the east by quartz rock and graywacke. The strata of all these rocks run nearly northeast and southwest, and dip to the southeast. Taken as a whole, I am inclined to denominate the predominant part of the series *talco-chloritic slate*. Nor can I resist the impression, that the whole series is the graywacke slate, which, by the agency of heat, has been partially converted into argillaceous slate, talcose slate, chlorite slate, and hornblende slate; the heat not having been powerful enough completely to accomplish the transmutation. And the contiguity of granite and sienite would furnish the heat which this hypothesis demands.

But whatever may have been the origin of this series of rocks, a perusal of Von Oeynhausen and Von Dechen's paper on the junction of the granite and killas rocks of Cornwall, in England, has led me to the opinion, that they greatly resemble the killas of that country.*

The bed of steatite in this talco-chlorite slate in Smithfield, is not of a very interesting character in an economical point of view. That which is gray colored is so filled with brown spar (?) as to be almost useless. A greenish scaly variety, (chlorite slate?) however, occurs, which is interesting. Fine foliated greenish talc, also, abounds here. Decided chlorite slate is likewise abundant at the quarry and in the vicinity. The steatite lies about half a mile west of Blackstone river and of Maysville.

Dip, Direction, and Character of the Strata.

It is hardly necessary to say, that this rock is always schistose in its structure; though in the most compact soapstone, both the slaty and stratified structures are nearly obliterated. Yet in some portions of the bed, they are usually visible. In both these structures this rock corresponds very nearly with mica slate; except that the former is less contorted than the latter. Chlorite slate is particularly remarkable in the Hoosic range, for the evenness and beauty of its layers, comparing in this respect with argillaceous slate. In both structures, so far as I have observed, the dividing planes correspond: and I have never noticed a double set of strata seams.

Dip and Direction of the Strata in the Hoosic Mountain Range.

	Direction.	Dip.
Florida, eastern slope of Hoosic Mountain: the talcose slate alternating with mica slate,	N. and S.	70° to 90° East.
Middlefield,	do.	70° to 80° East.
Plainfield, Hawley, Charlemont, Rowe, Zoar, Cummington, Chester, (west part,) and Worthington,	N. and S.	nearly 90° East.
Somerset, Vt. (Iron Mine,)	do.	20° to 90° East.
Whitingham, Vt. (Limestone beds,)	N. and S.	30° West.

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* Philosophical Magazine, Vol. V. N. S. p. 161.

Rowe, (north part,)	E. and W.	South, small.
Whitingham, Vt. (Chlorite Slate,)	N. and S.	nearly 90° East.
Peru, (do.)	do.	perpendicular.
Windsor, (do.)	do.	between 70° and 80° E.

It will be obvious from the above statements, that the strata of almost all this deposit stand nearly at right angles to the horizon. Very different is the case with the talcose slate in Smithfield, R. I. Its predominant direction is nearly S. E. and N. W., and its dip upon an average, only about 10° to 15° N. E. Indeed, in many places it is nearly horizontal. The talco-chloritic slate in the east part of Smithfield and Cumberland, runs generally about 15° or 20° west of south and east of north, and its dip is 20° to 30° southeast.

The bed of steatite in Groton dips to the southeast at an angle of about 30°.

Mineral Contents.

This rock in the Hoosic mountain range, must be regarded as a metalliferous deposit. Perhaps the most important metal which it contains is iron. This is found principally in two places, viz. in Somerset, Vt. and in Hawley, Mass. Smaller masses have been noticed in other places; but not in sufficient quantity to be of interest in an economical point of view. At all these localities, the ore is found in distinct beds in the strata; and sometimes it has a slaty structure, having every appearance of a contemporaneous origin with the rock.

I have already remarked, in the first part of my Report, that the iron ore in Hawley embraces two species; the magnetic oxide, and the micaceous oxide. Both of them are of fine quality. The micaceous oxide, especially, is as beautiful as any which has been found on the globe, as the specimens will show. (No. 844.) This bed does not occur, as is usually stated, at the junction of the talcose and mica slate; but two or three miles within the talcose slate —that is, reckoning from its eastern margin.

The most valuable ore at Somerset is the magnetic oxide. With this, however, is associated, often in the same bed, the hydrate of iron. Several of these beds occur in the vicinity, and sometimes they are connected with dolomite. The magnetic oxide is generally granular, and often easily crumbled into powder, which possesses so much brilliancy that it has been used as a substitute for smalt. It is so highly magnetic that it strongly attracts the fragments of the ore that have been broken off, and exhibits decided polarity; so as to form very fine specimens of the natural magnet. (No. 845.)

I have been recently informed by Dr. Holland of Westfield, that magnetic oxide of iron occurs in large quantity, probably in talcose slate, in the northwest part of Blanford. The specimen which he gave me is very free from earthy impurities and highly magnetic.

The largest mass of iron ore in the region that I have undertaken to describe, occurs in Cumberland, Rhode Island. It is chiefly the magnetic oxide, and lies two miles northeast of the centre of that place. But no rock is visible for a considerable distance around this large hill of iron. Sienitic granite occurs, however, not far remote, in one or two directions, and so does talco-chloritic slate. And upon the whole, my belief is that the iron is connected with the latter rock. For the large deposites of this ore in other countries most frequently occur in the older schistose rocks, and rarely in granite.* In Massachusetts too, no mineral is so widely disseminated in talcose slate as magnetic oxide of iron.

A part of the Cumberland ore is beautifully porphyritic by the presence of crystalline masses of white feldspar. In another portion we find a mineral disseminated, which appears to be the ferrosilicate of manganese. Imbedded nodules of what appears to be serpentine are also found in the ore: and these substances probably do not a little injury to the ore. For I was told it did not yield more than 25 or 30 per cent of iron.

In the first part of my Report, I have given a full account of the native gold found in connection with magnetic oxide and hydrate of iron in Somerset, Vermont. The usual gangue of the gold is the hydrate of iron: but whether enough of the metal exists in it to render it an object to separate the gold, has not been determined. Usually quartz exists in connection with the hydrate of iron. This is porous and contains the hydrate, and exactly resembles the gangue in which gold has been found in the Southern States. For comparison, I have placed specimens from Somerset and from Virginia in the collection. (No. 848, 849, 850.)

This porous quartz and the hydrate of iron are very common throughout the talcose slate of Hoosic mountain; and the iron results, if I mistake not, as already mentioned, from the decomposition of the carbonate. Whether the hydrate at Somerset had such origin, I have no means of ascertaining; but if ever gold should be found at other places in this formation, I predict it will occur in connection with this hydrate of iron.

Quartz and hydrate of iron then, appear to be the immediate matrix of the gold of Somerset; and talcose slate the rock in which the quartz and iron are contained. It is rare that we can at once trace this metal so satisfactorily to its original bed. But so far as can be judged by specimens, we may expect that such will be found to be the situation of the gold in the Southern States. For those specimens contain quartz, hydrate of iron, and talcose slate. Nos. (848, 849, 850.).

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* Beudant's Mineralogie, Tome I. p. 622.

The geological situation of the Vermont gold corresponds remarkably with its situation in other countries; particularly in Brazil. It is described as occurring there, disseminated in a rock, called by Al. Bronainart, *Siderocriste* (*Eisenglimmerscheifer* of Eschwege,) and composed of quartz with the specular and magnetic oxides of iron.* These are the two species of iron ore that occur at Hawley: and it ought to be reccollected, that in the vicinity of the iron mine in that place, quartz predominates so much, that I have described the rock as a variety of quartz rock. It is said, indeed, that the siderocriste is connected in Brazil with mica slate. But in the rock at Somerset mica occurs: and I am by no means confident that some geologists would not regard it as mica slate; and besides, the mica and talcose slates are interstratified and otherwise more intimately mixed; so that I am disposed to believe that the formation which I have called talcose slate, in Massachusetts and Vermont, corresponds to that containing gold in Brazil, as nearly as could be expected in countries so remote. And although at Somerset the gold has been found chiefly in the hydrate of iron, yet it probably exists also in the magnetic oxide, and not improbably in the micaceous oxide at Hawley. The ferruginous breccia that covers the siderocriste in Brazil, and probably contains platina and diamonds as well as gold, has not to my knowledge been found in Vermont or Massachusetts; yet it may be found still, as very few researches have been made on this subject.

We ought to guard against the idea that all gold must occur in talcose slate, because we know that some does; and because the happy suggestion of Mr. Eaton on this subject led to the discovery of that at Somerset. For veins of quartz containing this metal traverse other rocks in France, Peru and Mexico. They occur in granite, gneiss, mica slate, argillaceous slate, and talcose slate.* Hence we may find it in all these rocks, which are so intimately associated in Massachusetts and Vermont.

Another interesting ore in the talcose slate of the Hoosic mountain range, is manganese. It exists in beds or interstratified layers in the slate, precisely like the ores of iron above described. These beds are found in Plainfield, and several of them occur near one another, at two principal places, which are represented on the Map: that is, we find smaller and larger beds within a few feet or rods of one another. These beds are rarely more than three or four feet thick. Their surface is black or dark gray, apparently the common peroxide of manganese. But on breaking open the the mass, we usually find its interior to be of a beautiful rose red. This ore has been recently analyzed by Dr. Thomson, and found to be a bi-silicate of manganese. In the stone walls, a little north-east of the meetinghouse in Cummington, numerous large blocks of this ore are found, which were probably transported thither from the beds above described, by a diluvial current from the north: though to reach this spot, they must have passed over a deep valley, through which a branch of Westfield river now runs.

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* See Tableau des Terrains, &c. p. 329: Classification des Roches, p. 83: and Dictionnaire D'Histoire Naturelle, Art. *Or.*

† Dictionnaire D'Histoire Naturelle, Art. *Or.*

One never meets with this bi-silicate of manganese, which is not coated over with the black oxide. I hence infer that atmospheric agencies produce this conversion. As the bi-silicate is rare in other parts of the world, (indeed Dr. Thompson regards this as a new species, distinct from the siliceous oxide, on account of the double proportion of silex which it contains,) its great abundance in Plainfield and Cummington is a matter of joy to mineralogists.

Connected with the bowlders of this manganese ore in Cummington, I found small but well characterised masses of carbonate of iron.

The manner in which the above ores of iron and manganese occur in the talcose slate, forbid, it seems to me, the supposition somewhat extensively adopted of late,* that all metallic deposites in solid rocks have resulted from sublimation, through the influence of the heat produced by rocks of igneous origin. For although the layers of the slate are nearly perpendicular, and therefore sublimed matter might easily rise to fill a cavity from beneath, yet there seems to be no more evidence that these ores were thus introduced, than that the folia of the slate had such an origin; for the ores as well as the slate are distinctly foliated, and often both are intimately intermixed. What objection is there, in such cases, against regarding metallic deposites as having proceeded from solution and suspension in water, just as we now find iron and manganese forming; and subsequently rendered compact and crystalline by the heat of the unstratified rocks?

In the beds of steatite that have been described, several minerals of interest occur. Foliated bitter spar exists in almost every one of them; especially at Middlefield, Windsor, Zoar and Marlborough, Vt. At Middlefield it is sometimes three or four inches in diameter, enveloped in masses of delicate green talc; and is either white or of a salmon color, so as to form elegant specimens, as may be seen in the collection. In Zoar and Marlborough, and also in connection with the serpentine in Newport, R. I. the collumnar variety, called miasite, occurs. In Marlborough and Newfane, Vt., are found also those insulated rhombohedral crystals, which Mr. Brooke describes as a new species, under the name of carbonate of magnesia and iron. In the rhomb spar of Middlefield, sometimes occur tremolite and hepatic sulphuret of iron. The ligniform and compact varieties of asbestus are found in the same steatite bed. They exist also in Zoar, where they are associated with the new mineral picrosmine. At the soapstone quarry in the east part of Windsor, has been found a small quantity of chromate of iron of good quality. Sulphuret of molybdenum is said also to have been found in the Middlefield steatite; and the variety of talc called nacrite, occurs half a mile west of the meeting house in that town.

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* See an article by A. L. Necker Philosophical Magazine, Sept. 1832. p. 225.

No mineral is more common at these steatite beds than actynolite. It is in bladed crystals, long and slender, yet generally very distinct, being mostly six sided. It is found at Middlefield, Windsor, Zoar, &c. But the finest specimens come from Blanford, Mass., and Newfane, Vt. At the former place it is sometimes in radiated masses.

It has been already stated that imperfect crystals of hornblende are sometimes disseminated in one variety of talcose slate. The finely fibrous hornblende I have also found in quartz belonging to this same rock. But the most remarkable variety of this mineral is the fasciular variety. The laminæ, sometimes three or four inches long, and generally more or less curved, are disposed perpendicularly to the layers of the slate, so that their edges appear on the surface. When that surface is light colored, as in Nos. 864, 865, the distinctness and regularity of the fasicular and scopiform groups of hornblende are very striking. I am disposed to believe this to be a variety of horblende not described: and certainly if it deserves a distinct name, none can be more appropriate than *fasciculite*, under which I long ago described it in the American Journal of Science.

The chlorite slate abounds, throughout its whole extent, with distinct crystals of octahedral iron ore. They exist also in the common talcose slate, but not so frequently. The chlorite slate in Windsor, also, near the most eastern soapstone quarry, contains numerous crystals of the red oxide of titanium, imbedded in the feldspar, or rather in graphic granite, which frequently occupies the seams of the slate, or forms small irregular masses in it. But although the specimens are fine, it is with extreme difficulty that they can be obtained. It is a fact worthy of notice, that this rock in Scotland, where it is traversed by quartz veins, abounds in titanite; showing a very great similarity in the causes by which it was produced in distant countries.

Blue and green carbonate of copper are found in several places in Cumberland, R. I., in what I have described as talco-chloritic slate. The same rock abounds in epidote, sometimes finely crystalline, according to Dr. Webb. And I infer from his description, that the yenite associated with magnetic oxide of iron, is contained in the same rock. 'The steatite of Somers,' says Mr. Chapin, who will be again referred to in describing 'serpentine, affords a variety of minerals: e. g. the sulphurets of iron, copper, tin, (oxide ? E. H.) and molybdenum and virgin sulphur in geodes.'

Theoretical Considerations.

The views that have been presented relative to the origin of mica slate, are applicable, almost without variation, to talcose slate. The arguments proving that water must have been the earliest agent in the production of mica slate, prove the same of talcose slate; as do those evincing the subsequent action of a high degree of heat. To what circumstance the great abundance of magnesia in the talcose slate is owing, it may be impossible perhaps ever to determine. But its presence being once admitted, it is easy to conceive how talcose, instead of mica slate, might have resulted.

There is, however, one variety of talcose slate, which occurs half a mile west of the meetinghouse in Hawley, and affords an evidence not found in our mica slate, of the action of heat sufficient to produce an almost perfect fusion. I refer to the porphyritic variety, which I do not find described in European works. It seems to me that everything which we know of the chemistry of crystalization, forbids the supposition that the porphyritic structure can ever result from any other than an igneous solution. For in what laboratory have distinct crystals been produced in the midst of a mass essentially uncrystalized, except from heat? But it is well known that the porphyritic structure is not unfrequently met with in rocks whose volcanic origin is certain; even in the products of existing volcanoes. What, then, but an unreasonable attachment to hypothesis, should lead us to impute that to watery solution, which, so far as facts have come to our knowledge, has never resulted but from igneous solution?

In the present instance the almost entire absence of stratification and a slaty structure in the rock referred to in Hawley, gives additional probability to the idea of its having been once in a state of fusion.

12. SERPENTINE.

Perhaps there is no rock whose true nature and geological relations are so little known as serpentine. Its external characters are not, indeed, obscure; and analysts have given, probably with accuracy, its ultimate elements. But is it an altered or unaltered rock? If altered, what was the original rock? Is it stratified, or unstratified? primitive, or transition? These are questions on which geologists are not yet agreed. The Dictionnaire Classique D'Histoire Naturelle, says, that serpentine is 'principally situated in the latest of the primitive rocks and in the intermediate class.' Brongniart doubts whether it is found so low as the primary rocks; (*terrains agalysiens;*) and he says that 'no rock of this group, (*Ter. Plut. Ophiolithique,*) exhibits even a tendency to stratification.'* De La Beche classes it with the unstratified rocks.† But Dr. Macculloch considers it as sometimes stratified and sometimes unstratified; and accordingly ennumerates it in both these classes;† and also as a venous rock. He says, also, that it occurs in connection with granite, gneiss, micaceous, chlorite, and argillaceous schists. His account of this rock corresponds most nearly with its characters in Massachusetts; and here if I mistake not, it is almost always stratified. At least, the exceptions are less important than in the case of limestone; and since I have placed all our limestones in the stratified class, I shall do the same with our serpentines. In almost all cases, also, our serpentines are connected with the oldest rocks; such as gneiss, mica slate, and talcose slate: and if we have any rocks that are primitive, serpentine is one of the number.

Mineralogical Characters.

1. *Compact Serpentine.* This embraces two mineralogical varieties, the common opaque serpentine, and the translucent, delicate green, noble serpentine. They are of various degrees of hardness, and their fracture is sometimes splintery, sometimes granular, and sometimes foliated-splintery. The colors and their intermixture are very various. (Nos. 870 to 885.)

2. *Serpentine and Talc.* The talc is either foliated or in the condition of steatite. Often it is very obvious that the specimen is in an intermediate state between serpentine and steatite. Indeed, all the gradations between the two rocks may sometimes be seen, particularly in the beds of serpentine and steatite embraced in gneiss, in Pelham, Shutesbury, and New Salem. The color of the rock in these cases is quite black. (Nos. 886 to 893.)

3. *Serpentine, Talc, and Schiller Spar?* In this variety, also, the serpentine, as well as the foliated mineral which I presume to be schiller spar, are black; while the talc is green, and sometimes quite brittle. This variety occurs only in Blanford, Russell, and Westfield, so far as I have observed. (Nos. 894, 895.)

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* Tableau des Terrains, &c. p. 350.

† Geological Manual, Second Edition, p. 487.

‡ System of Geology, Vol. 2. p. 197.

4. *Serpentine and Carbonate of Lime.* The latter mineral in this variety is white, and the former green, or black. The proportions in which they are mixed is very various. The limestone is generally saccharoidal, and thus this rock forms the *Ophicalce Grenue* of Brongniart, who refers to Newbury as one of its localities. (Nos. 896 to 899.)

Other minerals found in serpentine sometimes essentially modify its characters: such as actynolite, asbestus, massive garnet, compact feldspar, &c.: but such varieties are hardly worth noticing in this connection.

Topography, Stratification, and Associated Rocks.

Since I have so particularly described the localities of our serpentine in the first part of my Report, it may be practicable, without confusion, to bring together all that I know of its stratification and associations, in a topographical order.

It will be seen, by the Map, that the most numerous and important beds of this rock occur near the central parts of the Hoosic mountain range, and especially in connection with, or in the vicinity of, the talcsoe slate. In Windsor are two beds. The most easterly bed is only a few rods from a bed of steatite; the latter appears in the hill forming the south bank of a branch of Westfield river, and the former in the opposite bank. Both the beds are obviously interstratified with chlorite slate, not far from the junction of this rock with common talcose slate. Its color is a pleasant rather deep green; its structure between granular and splintery; and it contains small disseminated fragments of chromate of iron. It is distinctly stratified; the strata running north and south, and standing nearly perpendicular; which is the usual dip of the rocks in the vicinity; though the chlorite slate, a few rods east of the serpentine, dips east about 70° or 80°. Not only is this serpentine stratified, but I observed here, as well as in the same rock in the west part of Chester, a structure which might properly be called schistose; especially where the rock had been weathered. The slaty laminae, however, are rather thick and irregular, nor do they extend through the whole bed.

The other serpentine locality in Windsor, is in the northwest part of the town, on land of Samuel Chapman. It occurs at the surface only in large bowlders; though I cannot doubt but it exists in place beneath the diluvium. The rock surrounding it is gneiss alternating with mica slate. The serpentine resembles that in Zoar, and like that passes into steatite so insensibly, that the eye cannot distinguish between the two minerals;—and specimens may be found in every intermediate degree of hardness. But the serpentine greatly predominates.

The situation of the serpentine in Zoar, is similar to that of the first bed in Windsor, just described. It occurs on the north side of Deerfield river; and the lateral edges of the strata are here laid bare. They consist of talcose and mica slate, with green and white steatite interstratified, the strata being not far from perpendicular. As nearly as I could ascertain, there are several beds of the serpentine at this place: though the numerous fragments of the rocks that are broken and mixed along these cliffs, render it difficult to determine all the alternations. It may be of consequence to remark, that in one instance at least, I noticed the serpentine lying next to the steatite. The serpentine at this locality is the common variety, and uniform in its color; but of a lively green. In some instances there is a mixture of the serpentine with the steatite.

In Marlborough, Vt. a little north of the limits of the Map, is a very extensive bed of serpentine; some parts of which, at least, are distinctly stratified. In the west part of New Fane is another bed, in which I do not recollect any marks of stratification; though it is several years since I visited the spot. Other large beds occur farther north, in Vermont, as at Grafton, Cavendish and Windham, and they are found in a continuation of the same talcose and mica slate range in which they exist in Massachusetts.

The most northern bed of serpentine in Middlefield is connected with the bed of steatite in that place already described. The bed in the south part of the town is the largest in Massachusetts; being from four to six miles long, and perhaps 80 or 100 rods wide. It extends into the west part of Chester, where it appears on the east side of Westfield river, rising to the height of 300 to 400 feet; and is succeeded on the east by talcose slate, which rises still higher. I examined this rock in the south part of Middlefield, and found it distinctly stratified; the strata running a little east of north, and dipping easterly, from 70° to 80°; corresponding, in these respects, with the adjoining strata. On the west this bed is succeeded by distinct hornblende slate, both in Middlefield and Chester. In the latter place the serpentine is stratified with a good deal of distinctness, and exhibits also a slaty structure. The dip, corresponding with that of the talcose slate on the east, and the hornblende slate on the west, is nearly perpendicular; and the direction rather more, east of north than in Middlefield. Forming the east bank of the river, the ledges of this rock seem to have suffered much from abrading agents; and the surface is much broken to pieces and the sides very steep.

I observed the Flora of this serpentine ledge to be rather peculiar. It abounds with the sassafras and Prunus borealis; the former of which, especially, is scattered rather sparsely over the neighboring hills. Polygala paucifolia, Saxifraga pennsylvanica, and Convallaria bifolia, I noticed also in great quantities. Ilex canadensis I observed likewise, as well as a rare species of Arenaria. Lichens and mosses, however, are rarely seen upon this serpentine.

Specimens that may be called noble serpentine do occur in Middlefield; but for the most part the rock is the common variety, of a pale green color, and somewhat foliated structure, abounding, however, in dark spots from the presence of chromate of iron.

Following the direction of the strata southerly from Middlefield a few miles into Blanford, we come to the bed of limestone, discovered since the first part of my Report was finished, and which I have already described. Little more than a mile north of this limestone, and about five miles northwest of Blanford meeting-house, on the old road to Becket, and on the northeast side of a pond, there exists a bed of serpentine which shows itself at the surface over a space about 30 rods in diameter, and it rises 30 or 40 feet above the general level. This large bed evidently occupies the same geological position as that in Middlefield; for the hornblende slate, frequently epidotic, lies in immediate contact with it on the west side; and though no rock in place appears on the other side, yet we have much reason to believe that talcose slate, or talco-micaceous slate, exists there. Not improbably this serpentine is connected without interruption with the Middlefield deposite. This would make the whole bed ten or twelve miles long.

The Blanford bed is for the most part as distinctly stratified perhaps as that at Middlefield; and its tendency to a slaty structure I think more distinct. The dip and direction of the strata seem to correspond to those of the hornblende slate in immediate contact, viz. the direction north and south, and the dip east, 60° to 70°.

The chromate of iron mentioned in the first part of my Report, is the most interesting, and indeed the only mineral that I noticed in this serpentine. It is disseminated through the rock in grains, and also forms veins or tuberculous masses resembling magnetic oxide of iron; being black and granular, or compact. But I judge it to be chromate of iron for the following reasons. 1. It has communicated a peach blossom color to small portions of steatite or talc that adhere to its surface. 2. The color of its powder is a dark brown. 3. It is not magnetic. 4. Fused with borax, it produces a beautiful green glass.

Should this mineral be found in considerable quantity at this place, it would be quite important in an economical point of view, since it sells in market from 40 to $60 per ton. I am inclined to believe it disseminated in small grains through nearly all the serpentine of the Hoosic mountain range, and not improbably large masses of it may be found in various places.

Since the publication of the first edition of this Report, Dr. H. Holland of Westfield, has examined the chromate of iron at Blanford, and does not find it very abundant. But 'at Chester, north of Blanford about five miles, I have discovered,' he says, 'quite a vein. The ore is more compact and rich than that from Blanford, which yields only about 30 per cent. of chrome. I have made the chromate and bi-chromate of potash and lead, and intend making the pigment, chromic green: The only compound of chrome that will defray the expense of manufacturing, even if the ore cost nothing. This ore is now only $35 per ton, stamped and made fine.' These statements of Dr. Holland are fully confirmed by specimens which he has kindly presented to me, both of the Chester chromate of iron, and of the beautiful salts which he has obtained from it. I cannot but hope that the effort which he is making in this manufacture may be successful; and I am confident that the one will be found abundant in most of our serpentine deposites.

Four or five miles south of this bed of serpentine in Blanford, is another, not more than 40 to 50 rods east of the soapstone quarry one and a half miles southwest of the centre of the town, which has been described. This serpentine is in mica slate, which dips easterly; and it is distinctly stratified. There is nothing striking in its appearance. The width of the bed is several rods.

I have reason to suppose that another bed of serpentine exists in the eastern part of Blanford, though I have found only bowlders. But the specimens are of so peculiar a character, that I cannot refer them to any known bed. They consist of green serpentine, talc, and sometimes schiller spar? (No. 892.)

The serpentine bed in Westfield is in mica slate, whose layers lean only a few degrees to the west. I speak here of the most southerly point of its appearance. Here it is about four rods wide. It occurs near the junction of the new red sandstone and the mica slate. This mica slate contains numerous veins and protruding masses of granite; and one mass of this rock lies within three or four feet of the serpentine, if it does not actually touch it. The serpentine is distinctly stratified; the dip and direction of the strata conforming to those of the mica slate. Its predominant color is black; but it contains a mixture of indurated greenish talc, and an amphibolic mineral of a gray color. (No. 893.) A considerable part of the rock, however, contains granular carbonate of lime: or rather in some parts of the bed this mineral predominates, and the serpentine is disseminated through it in small pieces. (No. 899.)

Nearly half a mile north of this spot, serpentine again appears on the north bank of Westfield river in Russell; and I have strong reasons for believing it to be a continuation of the bed in Westfield just described. The rock in Russell is a mixture of black serpentine with green, the latter being sometimes very compact and traversed by veins of indurated talc (?) or Deweylite. (?) (No. 885.)

I can hardly doubt but many more beds of serpentine might easily be discovered in the Hoosic mountain range, if ever it shall be an object to make such discoveries. I make this inference from the fact that I have found some of those above described, under circumstances the most unfavorable.

On the east side of Connecticut river but few beds of serpentine have been found in Massachusetts. That marked in Pelham occurs in the southwest part of the town, and exhibits itself over an area of only a few square rods. One may doubt whether this rock should be called serpentine, or steatite: for these two minerals enter into its composition. In general, however, the latter, which is of a black color, predominates. It also contains a considerable quantity of asbestus. This bed lies in gneiss; although the actual contact is hidden by the soil. But at a little distance on both sides this rock appears, and no other rock occurs in the vicinity.

The steatite marked as occurring in Shutesbury appears to be passing in some parts into black serpentine; as may be seen from the specimen, No. 805. At the steatite bed in New Salem this change is still more decided, so that large blocks of what must be called black serpentine are found there. (No. 890.)

In giving an account of the limestone found at Newbury, I have mentioned nearly every important circumstance respecting the serpentine of the same spot. It occurs there in veins or irregular masses of only a few inches in diameter. It will be seen by the polished specimens that several varieties at this locality are very beautiful; but they are so intersected by various minerals that only small pieces can be obtained.

At one of the limestone quarries in Littleton, I observed that small masses of green serpentine were disseminated in the rock. (No. 489.) At Bolton, also, according to Dr. Jackson, it occurs in considerable quantity.

The only remaining deposite of serpentine within the limits of the Map, is in Newport, Rhode Island. And under graywacke I have already given so full a description of the situation and characters of this rock, that any thing more seems unnecessary in this place. From that account it is obvious that this serpentine belongs to a much later geological epoch than any which I have described; probably as late as the graywacke; and if there be any example in the region embraced by the Map, where the serpentine occurs in a vein of considerable size, Newport is the locality.

Mineral Contents.

Serpentine bears a strong analogy to steatite in its mineral contents, as well as in several other respects. Nearly all the simple minerals that have been described as existing in our steatite, occur also in the serpentine. The beautiful green amianthus of Newbury has already been mentioned, and the asbestus of Pelham; as well as the amphibolic mineral, (probably actynolite,) in Westfield. At the latter place well characterised actynolite occurs; and according to Mr. Emerson Davis, anthophylite also. Here is likewise found a mineral, occupying a vein nearly a foot in width, which has been called petalite. But in hardness it corresponds more nearly with scapolite. It needs farther and more accurate examination. At the same place, as well as in the serpentine at Newbury, we find massive garnet. In Russell, in a supposed continuation of the Westfield serpentine, are found veins of amianthus traversing the rock, which rock verges towards a mineral that occurs in the Middlefield serpentine, as well as that of Newbury, and has been denominated Deweylite, in honor of Prof. Dewey. Chalcedony is also found in the Middlefield serpentine; and it sometimes passes into hornstone. Large rolled masses of these minerals, sometimes weighing 200 pounds or more, often agatized have been found in Middlefield and Chester, which probably proceeded from some serpentine locality. Dr. Emmons says, that steatite is crystalized distinctly in the serpentine at Middlefield; and he does not regard these crystals as pseudo-morphous; although mineralogists have generally considered the crystals of steatite as such; and Beudant makes a distinct variety of them under the name of *pseudo-morphous steatite.* The crystals at Middlefield certainly correspond in form exactly to those of quartz. In the serpentine of that place drusy quartz occurs, which is extremely beautiful. In the serpentine of Newfane, Vt., a similar drusy quartz has been found abundantly. Here also occurs chrysoprase; and sometimes the small crystals of quartz occupying the cavities of the rock have the color of the chrysoprase. At the same place General Martin Field has discovered pimelite.

Theoretical Considerations.

The preceding description will show that the serpentine of Massachusetts corresponds essentially, as to position and character, with those serpentines in Europe that are connected with the oldest rocks. But I am not aware that any statements which I have made, will throw additional light on the obscure subject of its origin. From the statement of Dr. Macculloch * and De La Beche,† as to the connection between serpentine, trap, and limestone, one would be led to infer that the first mentioned rock might have resulted from a mixture of the trap and limestone. But the serpentine of Massachusetts does not favor such an idea. The precious serpentine of Newbury probably lies between sienite or greenstone and the limestone; and such is its position in the cases described by these writers. The Westfield serpentine also contains a mixture of carbonate of lime, and in one or two other beds it may be found in small quantity. But in general our serpentines are entirely separated from limestone; and in respect to the gneiss east of Connecticut river, containing one or two of these beds, the whole extensive range does not to my knowledge embrace a single bed of limestone. But in all cases, (except perhaps that at Newport,) our serpentines are associated with talc, either pure and foliated, or as steatite, or chlorite slate, or talc and quartz. The two minerals, (talc and serpentine,) are intimately blended together and pass into one another by insensible gradations. And in all the cases described by the writers above referred to, talc was present. Is it not natural then to suspect that serpentine is talc, or talc serpentine, altered by heat? And since the talc is schistose and the serpentine massive, the latter must must have been produced from the former. In some cases it is easy to imagine that the internal heat might have been powerful enough to produce perfectly fused, and of course compact serpentine, protruding among other rocks in the form of veins; while at other times the fusion was only partial, not sufficient to destroy entirely the stratification. The great similarity in the chemical composition of serpentine and talc also favors the idea that they had a common origin. Both are composed essentially of silex and magnesia, with a considerable proportion of water. What the original rock could have been, which, with one degree of heat or with heat applied under certain circumstances, could have been converted into talc, and with another degree of heat, or with heat applied under different circumstances, could have produced serpentine, I am at a loss to imagine; though we do find talcose rocks among some of the older of those that are fragmentary. But I make these observations with little expectation that they will stand the test of observation. It may be found that serpentine has been produced from various rocks, which contained the necessary ingredients. But that heat has been employed in its production, cannot, it seems to me, be reasonably doubted; nor that it is a *metamorphic* rock. And these facts explain at once all the diversities of opinion, respecting its stratification and relative age, which we find among geologists.

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* Edinburgh Journal of Science, Vol. I. p. 1.

‡ Manual of Geology, p. 497, 2d edition.

13. HORNBLENDE SLATE.

I use this name as a translation of Dr. Macculloch's *Hornblende Schist*; and I include under it the same varieties of rocks. These varieties are such as other geologists have described under the names of hornblende rock, hornblende schist, primitive greenstone, and greenstone slate; all of which, I believe, occur in Massachusetts. In reading Dr. Macculloch's masterly description of the primary rocks of Scotland, I can hardly conceive that he is not describing those of New England; so perfect is the correspondence. Hence I have followed that geologist in describing most of the primary rocks; though I reject some of his distinctions. But upon the whole, I know of no geological writer who will compare with him in treating of the older rocks. I can by no means say the same in respect to his account of the newer rocks. For he obviously endeavors to depreciate the value of an accurate knowledge of organic remains found in the secondary and tertiary rocks; and it is but too evident that the reason is, that he himself can make no pretensions to distinction in this department of knowledge. As to Dr. Macculloch's views of geological theories, also, in his last work, entitled 'A System of Geology,' whatever opinion may be entertained of their correctness as a whole, I think no one who carefully examines them, will hesitate to acknowledge them, every thing considered, as remarkably profound, ingenious, and judicious. This remark, however, ought perhaps to be limited to his theories in respect to the primary rocks, for the reason above suggested.*

I have thought it proper to make these remarks, because I have so often in this Report followed the opinions, and applied the theories, of Dr. Macculloch, in the explanation of geological phenomena.

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* After having published so many separate geological works, and so many separate papers in the periodicals and transactions of learned societies, which were distinguished, for the most part, for the calm and dispassionate manner in which they were written, how unexpected to find in this last work, produced in mature years, so much of overweening self-conceit, so much of rude and overbearing intolerance, and of low jealousy and envy towards the distinguished school of geologists that are now advancing the science with unexampled rapidity! While he exhibits the principles of geology with a clearness and power to which I confess I know of no equal, he exhibits also a bitterness of feeling and violence of prejudice, to which, I had almost said, I know of no parallel. What a pity that a work, which might have gone down to posterity as a splendid monument of the commanding geological and chemical ability of its author, and have proved almost the 'Principia' of geology, should have infused into it so much of the leaven of depravity, as to excite disgust in the reader, strong enough to destroy almost every feeling of respect! Of the private history and character of Dr. Macculloch I know nothing. His geological writings alone have led me to make these remarks. May he live long enough to publish an expurgated edition of his System of Geology, and thus free his setting sun from that angry fiery cloud in which it is now eveloped.

All the varieties of rocks mentioned above, viz. hornblende rock, hornblende schist, primitive greenstone, and greenstone slate, occur, I believe in Massachusetts; and the system which regards them as separate formations, and some of them stratified and others unstratified, has long rendered their history obscure and perplexing. But by uniting them, as Dr. Macculloch has done, and regarding them as mere varieties of the same formation, very much of this obscurity vanishes. In Massachusetts their characters correspond with those given by the writer so often referred to. Although for a limited space the hornblende rock and the primitive greenstone appear, without close inspection, to be unstratified, and wanting in a schistose structure; yet the unstratified character is very limited, and a fresh fracture will commonly reveal an obscure slaty structure.

Mineralogical Characters.

1. *Of Hornblende alone.* Sometimes this variety is laminar, and sometimes fibrous. When fibrous, it is slaty; when laminar, no slaty structure can be perceived, nor any stratification, even in beds of considerable extent. This is the rock that has been sometimes called *hornblende rock.* (Nos. 914 to 928.)

2. *Hornblende and Feldspar.* Generally the hornblende is crystalline, and the feldspar foliated, or granular; but sometimes both ingredients are compact, and this mixture forms a good example of *primitive greenstone.* In this variety there is usually little appearance of stratification, or of a schistose structure; though this is not generally true of the whole bed. And sometimes, as in Whately, where this rock often assumes a columnar appearance, a schistose structure may still be seen. Sometimes the feldspar in this rock, as in the west part of Northfield, is finely granular, or even assumes a pulverulent appearance; while the hornblende is distinctly crystalline. When the ingredients are both crystalline, the rock furnishes a good example of hornblende slate. This variety is usually interstratified with gneiss and passes insensibly into that rock. (Nos. 929 to 951.)

In Whately is a curious variety of hornblende slate, in which the hornblende is light green and the felspar white and compact. A casual inspection would leave the impression that the rock is sienite. But a little attention shows a very decided slaty structure. The hornblende also predominates. This is the only example I have met with, in which the slaty variety contains compact feldspar without being porphyritic. (No. 947.)

Associated with a large proportion of the hornblende slate in the vicinity of Connecticut river, is a variety that falls under the present division, that is most decidedly, and sometimes very beautifully porphyritic. The feldspar is yellowish white, between foliated and granular, although sometimes retaining the form of the crystal in considerable perfection. The hornblende is sub-crystalline, and in the greatest quantity. Sometimes scales of mica are present. The slaty structure may usually be seen in this variety, though less distinct than in most other varieties of this rock. There is scarcely a more distinct variety of porphyry in the State than this; and as it admits of being smoothed, and probably polished, it would form undoubtedly an interesting ornamental stone. It is more common to meet with this rock in rolled masses than in beds; and hence I infer that its beds are rather limited. (Nos. 944 to 946.)

I have found a remarkable variety of this porphyritic hornblende slate in Canton and Easton, near the Blue hills, and also in Waltham, in rolled masses. Its peculiarity consists in the feldspar being compact, exhibiting the form of the crystal. The feldspar is white and the schistose structure of the rock distinct. (Nos. 948 to 950.) Whence this rock originated I am unable to say; though probably somewhere not far from the outer limits of the granite range, which lies west of the greenstone and sienite around Boston. It is quite obvious that this rock must have been so nearly fused as to destroy the foliated structure of the feldspar, yet without essentially impairing its crystalline form.

3. *Hornblende and Quartz.* (Nos. 952 to 957.) In general, this variety probably contains some feldspar also. The hornblende in a crystalline state forms the principal ingredient. The quartz is granular. The rock is slaty; and is sometimes traversed by veins of quartz or granite. It does not form a common variety.

4. *Hornblende, Feldspar, and Mica.* This approaches to gneiss: but I do not call it gneiss when the hornblende predominates. The mica is usually in small quantity, and the feldspar and quartz sometimes traverse the rock in numerous minute veins, which seem to have been frequently cut off and shifted by one another. (Nos. 958 to 963.)

6. *Hornblende and Epidote.* This latter mineral sometimes constitutes so large a proportion of the rock, that I thought it ought to be regarded as a constituent of one of the varieties of hornblende slate. Generally it is granular and disseminated through the rock, giving it a peculiar green tinge: but sometimes it is imperfectly crystalized in cavities, and sometimes in veins. (Nos. 964, 964 1-2, 965.)

6. *Hornblende and Chlorite.* This variety is rather uncommon: but I have met with it in Whately, Shelburne, and perhaps some other places. Sometimes it passes into genuine chlorite slate. (No. 967.)

7. *Actynolite Slate.* This is found in gneiss in Shutesbury; and I know of no other well marked locality. It occurs near the

mineral well near the centre of the town. The rock is slaty and is composed of fibrous actynolite, foliated feldspar, mica, hornblende and quartz, arranged somewhat in layers. It is obviously only gneiss which takes into its composition a large proportion of actynolite. In Belchertown I found a loose specimen, in which the actynolite was granular and in large quantity, and the rock was not slaty. (Nos. 968, 969.) Since the ablest mineralogists now regard actynolite and hornblende as the same species, I cannot see how Dr. Macculloch can be justified in making a distinct rock of actynolite schist, as he has done. It certainly can lay claims to be considered only as a variety of hornblende slate.

I doubt not that other and still more compound varieties of hornblende slate might be found among our rocks: for this rock passes by imperceptible gradations into almost all those with which it is associated. Under talcose slate, I have noticed, for example, a variety containing hornblende, which might as well have been reckoned in this place. Under mica slate, I have also noticed an amphibolic variety, in which the hornblende sometimes predominates.

Topography of Hornblende Slate.

Every deposite of hornblende slate which I have examined in New England, is associated either with gneiss, talcose slate, mica slate, or quartz rock. The small patch represented on the Map in the vicinity of the beds of limestone in Smithfield, R. I., is apparently associated with talco-chloritic slate; though as we go westerly, we find it alternating with gneiss: indeed, I suspect these three rocks are sometimes interstratified. Much of the hornblende slate in the vicinity of the lime quarries, is decided primitive greenstone, and greenstone slate; and it also passes insensibly into the talco-chloritic slate.

Most decidedly associated with gneiss is the range of hornblende slate represented as extending northeasterly from Grafton to Billerica. In some places, as at Marlborough, its hornblende character is fully developed, and it there becomes as nearly greenstone slate perhaps as any rock in the State. But generally this stratum is more or less intermixed with gneiss, so that sometimes one sees only traces of it. Yet as I usually found the deposite well characterised in the region where it is marked, I thought it proper to give it as a continuous range on the Map. Generally between this hornblende slate and and the granite on the east, the surface is composed of diluvium, so as to hide the junction of the two rocks.

Extending from Stafford in Connecticut, to Athol, in Worcester county, the Map exhibits another narrow stratum of hornblende slate, very similarly situated to that just described. I have met with narrow beds of this rock still farther north, and probably it might with truth be extended across the whole State. But I saw it so rarely north of its present termination, that I thought it best not to carry it across the State. This rock is generally crystalline in its aspect, and is mixed with feldspar and quartz in considerable quantity: being obviously in nearly all cases, but a variety of gneiss. And it ought here to be remarked, that in many other places in the broad gneiss range of Worcester county, the rock takes so much hornblende into its composition, that it properly becomes hornblende slate. Some of these beds—as in Pelham—bear a closer resemblance to unstratified secondary greenstone than any other member of the primary rocks: indeed, I do not see but they must be regarded as genuine trap rock; (No. 1111.) and I have accordingly placed specimens from them among those of greenstone.

The deposite of this rock in the west part of Northfield, north part of Gill, and east part of Bernardston, is represented as in contact with mica slate, quartz rock, and new red sandstone: and such I believe to be its associations; though recent examination has led me to suspect that gneiss alternates with the mica slate. The hornblende slate of this region is sometimes slaty; but very frequently it is decided primitive greenstone, exhibiting even sometimes a passage into sienite. In some parts of the bed no marks of stratification, or slaty structure, appear; but they are almost uniformly present in other parts. In one instance, at least, a vein of white fetid quartz, nearly a foot wide, traverses this rock. This spot is on the road from Gill to Bernardston. The quartz near the edges of the vein contains foliated masses of feldspar.

Four other deposites of hornblende slate are represented on the Map, surrounded by mica slate, in the western part of Franklin county. I have recently ascertained that the deposite, which extends from Colrain to Conway, is associated with a limited stratum of gneiss, whose characters are fully developed in the east part of Buckland. The hornblende slate lies principally in the west part of Shelburne, occupying a high hill.

In respect to the other three patches alluded to above, I have no remarks to make, except to say that I do not suppose I have very accurately marked out their true limits, or situation. I know that in the vicinity of the spots where they are marked, I have repeatedly found hornblende slate. But I also know, that nearly all analogical reasonings as to the situation of this rock have failed me.

About one mile north of Whately meetinghouse, we find a limited deposite of hornblende slate, on the west side of the street, probably succeeding the red sandstone. Passing westerly not more than 100 rods, we cross almost every variety of this rock, that has been named: the common hornblende slate, which predominates: also that containing epidote, which is frequently divided into rhomboidal masses of considerable regularity: then we come to primitive greenstone, where the slaty and stratified tendency begins to be lost in the trappose or columnar: next we strike the peculiar variety, already described, as containing white compact feldspar: finally succeeds mica slate. In describing sienite I shall refer again to this spot.

The strip of hornblende slate marked along the eastern margin of the gneiss range in the west part of Hampden county, and the east part of Berkshire, is so intermingled with the gneiss on one side, and with the mica slate and talcose slate on the other, that it is no easy matter to fix upon its true position or extent. I have exhibited it in those places where I found it most abundant. But viewing it rather as a variety of gneiss, I do not regard its exact situation or extent on the Map of any great importance. Traces of this same rock may be seen all along the eastern margin of the talcose slate; and in Plainfield and Hawley, it is not uncommon to find examples of pure hornblende slate: though usually the hornblende forms the least abundant ingredient, and ought perhaps to be considered merely as crystalized hornblende disseminated through talcose slate.

Some of the hornblende rock in Granville and Tolland is laminated, and the size of the laminæ is often gigantic. In the latter place, half a mile east of the meetinghouse, I have seen imperfectly prismatic masses not less than a foot in length and one or two inches wide. I apprehend that this hornblende slate in these towns, is connected with the extensive ranges of that rock which one crosses in passing from Lee to Becket. But I am so doubtful about the true situation of this rock along the western part of the gneiss range in Berkshire county, that I have forebore to represent it on the Map. In the east part of Lee and west part of Becket, it is associated with augitic gneiss: and both these rocks are obviously varieties of gneiss.

In respect to the gneiss, hornblende slate, mica slate, and talcose slate, represented on the Map as occupying a considerable part of the Hoosic range of mountains, I take this opportunity to remark, that whoever expects in passing transversly or longitudinally over this region, to find as sudden and decided changes in the rocks as are shown on the Map, will be disappointed. On the Map the change must be represented as sudden: but I have often travelled for miles in that region, in great uncertainty what rock prevailed. In such cases, one can give the line between different formations only by approximation.

Dip, Direction, &c. of the Strata.

I cannot but regard the hornblende slate of Massachusetts, as belonging to the same geological epochs as the gneiss, mica slate, and talcose slate; that is, it seems to me they were all produced by essentially the same causes, and during the same periods of time. Hence we should expect, (if this opinion be correct,) that the dip and direction of the strata would correspond with those of the strata that have been mentioned. And such is the fact: though upon the whole, this rock approaches more nearly to verticality in the dip of its strata, than any other rock in the State; as the following notes will show.

	Direction.	Dip.
Middlefield, - - -	N. and S.	70° to 80° E.
Becket, east part, - -	N. and S.	90°
do. west part, - -	N. and S.	70° to 80° E.
Granville, - - - -	N. and S.	90°
Blanford, north part, - -	N. and S.	90°
do. northwest part, - -	N. and S.	60° to 70° E.
Rowe, north part, - -	E. and W.	South, small.
Chester, west part, - -	N. and S.	90°, nearly.
Shelburne, - - -	N. and S.	45° to 90° E.
Bernardston, east part, - -	N. and S.	50° to 60° E.
Monson and vicinity, - -	N. and S.	45° to 70° W.
Westborough, - - -	N.E. and S.W.	50° to 70° N.W.
Marlborough, - - -	N.E. and S.W.	80° to 90° N.W.
Cumberland, R. I. - -	N.E. and S.W.	40° S.E.
Smithfield, R. I., lime quarries,	S.E. and N.W.	30° to 45° N.E.

I have already alluded to the tendency of the hornblende slate to divide into rhomboidal masses. I have observed this no where so distinctly as at Whately. There, also, the masses sometimes affect a columnar form; (No. 938.) though perfect columns of any great extent are rarely the result.

This rock is frequently remarkable for the numerous and complicated contortions which its layers exhibit, often rivalling in this respect, mica slate and gneiss. Not unfrequently these irregularities appear to be increased by the passage of granite veins through the rock, as in Granville.

Mineral Contents.

So far as it has been examined, no rock in the State appears to be so barren of interesting minerals as this. Garnets are perhaps the most common, and generally they are of a blood red color—probably in some cases the pyrope. In Rowe, epidote occurs in this rock in a state of such purity that it deserves to be mentioned.

In Middlefield and Chester, sphene has been observed in it. In its cavities also, not unfrequently, as in Charlemont and Whately, I have noticed tolerably distinct crystals of feldspar. The immediate gangue of the plumbago mine at Sturbridge is hornblende and feldspar; and the former minerals constitute the gangue, to a considerable extent at least, of the arsenical cobalt of Chatham, Ct. Red oxide of titanium I have also found in hornblende in Leyden. Other minerals will undoubtedly be discovered in this rock, upon farther examination. Hitherto mineralogists have paid very little attention to the geological situation of localities in our country.

Theoretical Considerations.

It easy to apply to hornblende slate the theory which imputes to the primary rocks an origin partly aqueous and partly igneous. For it is a very fusible rock, and may hence easily be conceived to have been sufficiently heated to enable it to assume the crystalline aspect, which it almost always exhibits. But from what rock did the hornblende slate originate? The researches of Dr. Macculloch appear to have thrown a gleam of light upon this difficult question, 'As far as a single fact can prove such a case,' says he, 'the origin of hornblende schist from clay slate is completely established by the occurrence in Shetland of a mass of the latter substance, alternating with gneiss and approximating to granite. Here those portions which come into contact with the latter, become first, siliceous schist, and ultimately, hornblende schist; so that the very same bed which is an interlamination of gneiss and clay slate in one part, is in another, the usual alternation of gneiss and hornblende schist.'* In another place he says, 'it would appear that the fusion of clay slate, whether primary or secondary, is, under various circumstances, capable of generating, either the common trap rocks, or the hornblende schists: nor is it perhaps difficult to explain, by a more gradual cooling, and consequently, a slower crystalization, the particular causes which may have determined the latter rather than the former effect.'†

This theory, if admitted, explains satisfactorily the approximation of hornblende schist to unstratified trap rocks. For some portions of the clay slate would very probably be so entirely fused as to obliterate all marks of a stratified and schistose structure: and hence by slow crystalization might result hornblende rock and primitive greenstone.

I have observed no facts in Massachusetts very decisive in respect to this theory. But since granite does occur in connection with some portions of our clay slate, I doubt not but such may be found here. I have made no examination on the subject worthy to be named. It is my opinion, however, from what I know of the range of slate extending into Vermont and New Hampshire from Franklin county, that in those states would be the most likely places for such facts to be developed. The passage of graywacke slate into talco-chloritic slate, and of this into hornblende slate in Smithfield and Cumberland, Rhode Island, has probably also a bearing upon this theory.

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* System of Geology, Vol. I. p. 210.
‡ System of Geology, Vol. II. p. 171.

The remarks that have been made in relation to porphyritic talcose slate, will apply with still more force to that variety of hornblende slate which is porphyritic. For in the latter case this structure is more distinct and perfect than in the former. And the the more I reflect upon the subject, the more satisfied I am, that a porphyritic structure must, in all cases, have been the result of the agency of heat.

14. GNEISS.

This rock occupies more of the surface in Massachusetts than any other: and in all countries of much extent hitherto examined it is one of the most extensive of the formations. Quartz, mica, and feldspar, are its common and essential ingredients; though hornblende is so often present, that some writers regard its claims to be considered essential, as equal to those of the other three minerals. It is obvious, therefore, that the mineralogical constitution of this rock is the same as that of granite. The only difference, indeed, consists in the stratified and slaty disposition of the gneiss. This character, however, sometimes becomes very obscure; and then it is almost impossible to distinguish between the two rocks. They might, therefore, be regarded as varieties of one another: differing only in the mode of their production, as in the case of the stratified and unstratified limestones and serpentines. Little advantage, however, would be gained by such an innovation; and granite and gneiss have so long been considered as classical terms in geology, that if possible they ought to be retained; lest that neological spirit, which vain ambition nourishes, should unsettle every principle of the science.

The gneiss of Massachusetts corresponds almost exactly to that described by European geologists, particularly by Dr. Macculloch. Our gneiss, however, does not to my knowledge alternate with clay slate, as it does in Scotland. I am inclined also to believe, that ours exhibits a greater regularity of stratification, producing a fine rock for architectural purposes.

Although in general the characters of gneiss are tolorably distinct, yet an almost infinite variety of specimens may be obtained, slightly differing in the color, arrangement, or proportion, of the ingredients. They may, however, be reduced to a few leading varieties.

Mineralogical Characters.

1. *Granitic Gneiss.* (Nos. 972 to 992.) I suppose this variety to be the granite-gneiss of Humboldt. It certainly approaches very near to granite; and in hand specimens cannot be distinguished from a coarse grained variety of that rock. Even for an extent of several yards, we can sometimes discover no marks of a schistose or stratified structure; but those structures, at least the schistose, usually appear at no great distance, to prevent our regarding the rock as granite. It might, indeed, on a superficial view, be considered as a vein of granite in gneiss. But the masses will be found too irregular for such a supposition; and often they are bounded on all sides by well characterized gneiss. It would explain the mode in which this rock presents itself, to suppose that a slaty rock was once in a state of partial fusion, while some portions of it were perfectly melted, so as to crystallize in the form of a coarse granite; the principal part of the mass cooling before the slaty structure was entirely lost. In travelling several miles I have sometimes been at a loss to decide whether the rock were gneiss or granite, until a very careful examination disclosed a partially obsolete parallelism of the mica. I think, however, that there is a slight peculiarity of aspect in most of the granitic-gneiss of Massachusetts, which would enable me to distinguish it from genuine granite even in hand specimens, which were totally destitute of a parallel disposition of parts. But it is difficult to describe the exact nature of that peculiarity.

2. *Schistose Gneiss.* (Nos. 993 to 1022.) This is probably the most common variety of our gneiss. The structure is foliated like that of mica slate: though sometimes granular with a laminar tendency. Some of the best quarries in the State I regard as belonging to this variety. It passes frequently into mica slate by the disappearance of the feldspar.

3. *Laminar Gneiss.* In this variety the different ingredients occupy distinct layers. When the mica is black, or there is an interlamination of hornblende, the different laminæ are remarkably distinct and regular. In some instances, perhaps, this rock may be regarded as composed of alternating layers of gneiss and mica slate, or hornblende slate. (Nos. 1023 to 1040.)

4. *Porphyritic Gneiss.* The structure of this variety is more or less slaty. But it embraces distinct crystalline masses of foli-

ated feldspar. Most commonly these masses are somewhat ovoid; but in some instances they present the regular forms of the crystals. The color is sometimes white or gray: but a reddish hue predominates. The imbedded masses vary in size from a quarter of an inch in their longest direction, to two inches; and they sometimes constitute the largest portion of the rock. This variety sometimes answers well for architectural purposes. (Nos. 1041 to 1050.)

5. *Amphibolic Gneiss.* I thus denominate that variety which takes a small proportion of hornblende into its composition: not sufficient to form hornblende slate. This mineral is usually disseminated in black foliated masses, from the size of a pin's head to half an inch in diameter, through the rock. It occurs only in the vicinity of hornblende slate. (Nos. 1051 to 1054.)

In the southeastern part of Worcester county is a beautiful rock, extensively quarried, which I refer to this variety. One meets with it abundantly in Mendon, Grafton, and the south part of Worcester, in blocks got out for building; but I do not know where are its quarries. The rock appears to be a granitic gneiss, composed almost entirely of quartz and feldspar, through which are disseminated numerous black crystalline masses of hornblende, which have a somewhat parallel arrangement. This parallelism is almost the only mark by which I distinguish this rock from granite. It might with propriety be termed *sienitic gneiss.* (Nos. 983 and 986.)

Epidotic Gneiss. This variety usually contains hornblende as well as epidote. The latter mineral is very frequently in veins and generally compact. It is sometimes, however, disseminated through the rock, giving it a peculiar green tinge. Were this not a common variety of gneiss, especially in the vicinity of hornblende slate, it would not deserve a distinct description. It is closely allied to the epidotic hornblende slate. (Nos. 1055 to 1061.) When the epidotic gneiss happens to be porphyritic, it forms a beautiful ornamental stone. (No. 1043.)

7. *Augitic Gneiss.* This interesting rock is usually composed of quartz, feldspar, and lively green augite, in coarse grains or partially crystalline masses. Occasionally we see present grains of black hornblende. The augite seems generally to have taken the place of the mica. The augite is disseminated in various proportions through the mass and the slaty structure is quite indistinct. (Nos. 1062 to 1065.)

8. *Anthophyllitic Gneiss.* In the west part of Enfield and in Belchertown, anthopyllite is disseminated through the gneiss in such quantity, that it deserves to be considered an ingredient of the rock, if it be proper thus to consider amphibole, epidote, and augite, in the three preceding varieties. This rock is composed

almost entirely of feldspar, quartz, and anthophyllite, the mica being rarely present. (Nos. 1066, 1067.

9. *Arenaceous Gneiss.* I have found this rock only in one well marked locality, viz. at Southbridge, Worcester county; but it seems to me sufficiently peculiar to deserve a distinct notice. It is composed entirely of quartz and feldspar, which, (particularly the latter,) are in a finely granular slate; embracing, however, small but distinct crystals of red garnet. Between the layers of the rock we find a substance which approaches to talc. This rock is quarried and is employed for lining furnaces. (No. 1068.) Perhaps it ought to be described under the next variety.

10. *Talcose Gneiss.* This is composed of feldspar, quartz, and talc; the first ingredient in the largest proportion. Its structure is irregularly schistose: but it has the aspect of a rock formed in part by mechanical agency. As I have met with it only in one place, (between Smithfield and Providence, R. I.) and did not there examine it carefully, I am not prepared to say whether it ought to be regarded as the *Protogine* of European geologists. (No. 1071.)

Topography of the Gneiss.

There are in Massachusetts four separate deposites of gneiss: one in the Hoosic mountain range; two in the central parts of the State; and a fourth in the vicinity of New Bedford, in Plymouth and Bristol counties.

Hoosic Mountain Range.

Under mica slate I have already given a general description of the situation of this gneiss, and the reasons that lead me to suspect that it passes laterally, or in the direction of the strata, into mica slate. Throughout nearly the whole extent of Litchfield county, in Connecticut, this gneiss range is most distinctly characterised. As we proceed northerly into Massachusetts, its characters become less decided. The feldspar is less abundant, and the mica more so; and hornblende frequently abounds in it; so that viewed on a small scale, it may often be regarded as mica slate. Along the eastern slope of Hoosic mountain, the rock becomes sooner converted into mica slate than along the western slope. On this latter side, indeed, distinct gneiss continues nearly across the State, as may be seen on the Map; and I am by no means sure but careful research may trace it entirely across the State; so as to connect it with the gneiss that appears in the lower part of Vermont, along the eastern talus of the Green mountains. At any rate, that Vermont gneiss appears distinctly characterised in the southwest part of Whitingham, near the beds of limestone, as shown on the Map;

and from thence I have traced it as far north as the Somerset iron mine. Here then we have two edge-shaped ranges of gneiss, with their acute angles towards each other, while the space between them is occupied by mica slate and talcose slate; and sometimes we find these slates, for a limited space, passing into gneiss. There is certainly then some probability in the supposition that all these schistose rocks may belong to one formation; and that the varieties resulted from local peculiarities in the mode of formation.

In passing from Becket to Lee, we cross strata of decided gneiss, till within three or four miles of Lee, when the rock contains a considerable proportion of hornblende, and at length becomes decided hornblende slate. Still nearer to Lee, the hornblende is replaced by green augite, and augitic gneiss hence results. Within two miles of Lee, we meet with limestone; which often contains a mixture of augite; and this mineral, being decomposed at the surface, yet projecting beyond the limestone, the whole rock exhibits a brown and very rough and irregular aspect; exceedingly like similar compounds at the lime quarries in Bolton, Boxborough, Littleton, &c.—This augitic gneiss certainly deserves a more thorough examination than I have been able to give it.

In the western part of this gneiss range in Connecticut, beds of coarse saccharine limestone are common. But I have never been able to find one of this description, in Massachusetts; though I suspect their existence, as in New Marlborough.

The limited patch of gneiss marked on the Map, in Buckland and Shelburne, lies chiefly in the ravine through which Deerfield river passes. In its most elevated parts, (as on the western slope of the high land in the west part of Shelburne, and on the opposite side of the river in Buckland, on the stage road between the two bridges over Deerfield river,) this rock is very regular in its stratification: but at the bottom of Deerfield river, at and below Shelburne Falls, it is the granitic gneiss, almost destitute of stratification, and contains hornblende. The feldspar here is in small proportion; and some of the rock might properly be denominated quartz rock.

These facts have led me to inquire, whether the greater regularity of stratification in the higher parts of this deposite, might not proceed from the fact, that the lower parts are nearer to that igneous power, which, according to the theory that I have elsewhere explained, has partially fused some portions of the primary rocks, and entirely fused other portions? Here the upper strata are perfectly regular and continuous: but as we descend, we find the rock approximating nearer and nearer to unstratified granite, yet retaining some faint traces at least of a schistose structure. Is it reasonable to suppose, that a little deeper excavation would disclose perfectly well characterised granite? The light which I fancy this spot throws upon theory, is the most interesting circumstance connected with this deposite.

Worcester County Gneiss.

The broad ranges of gneiss in the central parts of the State, which for distinction's sake may be called the Worcester county ranges, next claim attention. That range, which lies west of the mica slate deposite in Worcester valley, extends across the whole of Connecticut to Long Island Sound on the south, and probably through all the western part of New Hampshire, and I know not how much farther north. The most elevated point of this range in Massachusetts is Wachusett mountain, in Princeton, which rises 3000 feet above the level of the ocean. This is a remarkable insulated peak, nearly twice as high as any other part of Worcester county. Its stratification does not exhibit much of that irregularity, which we should suppose must have resulted from its having been elevated so much above the surrounding country: though its stratification is certainly very obscure. And I am rather inclined to ascribe such an origin to this mountain, than to suppose the surrounding country to have been once equally elevated and subsequently worn away; since the rock composing it possesses no peculiar power of resisting disintegration and abrasion, that is not possessed by the gneiss of the whole range.

I would repeat here, however, a remark made under diluvium, that the gneiss rock of Massachusetts appears to be peculiarly liable to disintegration; especially where it abounds in sulphuret of iron. Hence it is that the gneiss region of Worcester county furnishes so excellent a soil. As we go westerly upon this range, and get into the limits of Hampshire and Franklin counties, more of the naked rock appears; and the soil generally is much poorer. But in Worcester county generally the rock appears in place but seldom; and the hills are much rounded. In the gneiss region of Hoosic monntain, that has been described, the hills are generally steeper, and the country for the most part more elevated. The soil also, is not as rich or deep as in Worcester county.

I have reason to believe, though not from personal examination, that the Monaduc and White mountains in New Hampshire, are essentially composed of gneiss, and insulated in a manner similar to Wachusett: being in a continuation of the same range.

Porphyritic gneiss prevails extensively along the western margin of the Worcester county gneiss range, in the town of Northfield, Mass., and Winchester, N. H. It appears also very conspicuously on the high hill east of Ware village. This is one of the most rocky spots in the State; and the crystalline masses of feldspar are here unusually large. This range of porphyritic gneiss extends northerly through Dana, Petersham, &c., lying immediately east of the hornblende slate exhibited on the Map. It can be traced south from Ware also, through Palmer, &c. Indeed, it is the most extensive deposite of this variety of rock I have ever found. It appears that the peculiar causes that produced it, operated over a great extent. Judging from the great regularity of the rock formatians in this country, I predict that a strip of it may be found extending northerly from Long Island Sound as far as the gneiss reaches.

From Hubbardston, both north and south, to the boundaries of the State, and in breadth several miles, the characters of the gneiss are greatly obscured by the iron aspect which the rocks have assumed in consequence of the decomposition of pyrites. The same appearance is frequent in other parts of the range.

Granitic gneiss abounds in various parts of this deposite: but rather more I think in the southern than in the northern part of the State. In the west part of Charlton, for instance, and so occasionally all the distance to Brookfield, one is often at a loss whether the rock be gneiss or granite. In Uxbridge, in the range east of the mica slate, the same variety abounds; and still more frequently on the east side of the Blackstone in Mendon.

That range of the Worcester county gneiss just referred to, which extends northeasterly into Middlesex county, posseses some peculiar characters. In another place I shall attempt to show, from the dip and direction of the strata, that it belongs to a different system of stratification from the gneiss west of Worcester valley. But I refer now to other peculiarities. One is, that it contains numerous beds of limestone, which are entirely wanting in the western range. Another is, that it passes so frequently into mica slate; the two rocks often alternating, and indeed, in some places, the slate predominating. Indeed, it would not be strange if some future geologist should regard a part of this range as mica slate. A third peculiarity is, that it abounds, especially towards its northeastern extremity, in veins and protruding masses of granite.

I have found it very difficult to determine the exact eastern limits of the gneiss range under consideration. I mean the line of its junction with the granite. Much of the gneiss near that line is granitic, and of course difficult to be distinguished from granite. In some places the beds and veins of granite increase in number and size as we go easterly, until at length the gneiss occupies only a small proportion of the surface. Near the junction of the two rocks, also, diluvium is very abundant; which increases the difficulty of fixing their limits.

New Bedford Gneiss.

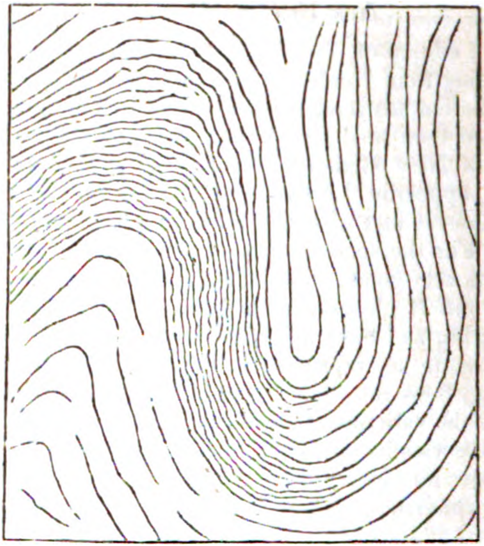
On the first edition of the Map, I represented a deposite of gneiss extending from Rochester to Little Compton: but subsequent examination has rendered it doubtful to my mind, whether any thing more than small insulated patches of this rock are to be found west of New Bedford. Gneiss of a peculiar character, does, indeed, appear in Little Compton; but in the intervening space I have never met with any rocks in place but granite; and this rarely. For the accumulation of diluvium in that quarter of of the State is very great; and, indeed, the towns of New Bedford, Fair Haven, and Rochester, might be regarded as dilluvial without impropriety; but as I have met there with gneiss in some instances, I do not hesitate to represent a deposite of gneiss in those places; being, however much in doubt as to its actual limits.

Almost all the varieties of gneiss that have been described, may be found in the vicinity of New Bedford. In that place it is schistose, and passes into mica slate. There, too, we find a beautiful variety of porphyritic gneiss in bowlders; the masses of feldspar being flesh red and about the size of a hazle nut.

Schistose and Stratified Structure: Dip and Direction of the Strata.

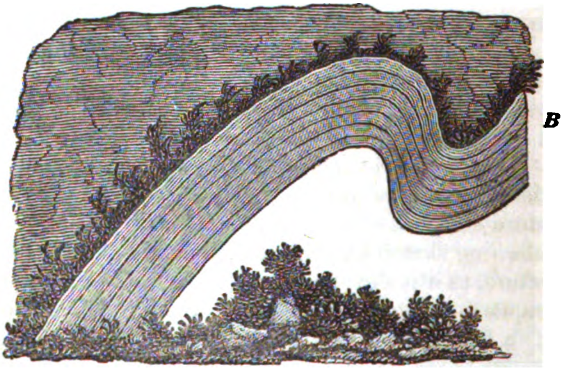
In no rock in the State are the slaty and stratified structures so distinctly marked in the same rock, as in gneiss. The strata are usually thick; and where no local cause of irregularity exists, remarkably even and continuous. Hence the facility with which the quarrymen cleave out slabs of gneiss, 20 or 30 feet long, and half as many wide. But these same slabs, when dressed, often exhibit a schistose structure of remarkable irregularity,—the laminæ being much bent and composed of different ingredients, so as to give to the rock the appearance of a variegated or clouded marble. The underpinning of most of the buildings in Amherst, particularly of the village church, exhibits this appearance most strikingly. The rock, however, will not cleave in the direction indicated by these contorted layers, any easier than in other directions. And hence, in strictness of language, it ought rather to be regarded as a foliated than a schistose structure. Hence, too, this structure does not injure the rock for architectural purposes.

The following sketch exhibits a very striking case of this foliated structure, as it is developed on the surface of a bowlder, several feet square, lying by the side of the road in Colebrook, Connecticut; a few miles south of the Massachusetts line. These curvatures are much larger than is usual and more distinct. They appeared to be entirely independent of the stratification.



Curvatures in the Folia of Gneiss: Colebrook, Ct.

These curvatures are not, however, confined to the laminæ of gneiss, but are sometimes seen in the strata. About one mile before reaching the meetinghouse, near the centre of New Marlborough, on the south side of the road, the traveller will see an overhanging ledge of stratified gneiss, dipping from 40° to 50° east, whose edges are bent as in the annexed sketch. The whole length of the strata here exhibited, (from *A* to *B*,) is 12 feet; and their breadth about four feet. This ledge has been described by



Curved Strata of Gneiss: New Marlborough.

Prof. Dewey, under the name of mica slate; but I have already given the reasons that have led me to differ from him on this point.

The suggestions that have been made in treating of mica slate, in regard to the causes of such flexures in rocks, are equally applicable to the rock under consideration; and therefore I shall add no more in this place on the subject.

It will appear from the following notes, relative to the dip and direction of the strata of gneiss in Massachusetts, that this rock conforms to at least three systems of stratification. The Hoosic mountain range, and the western part of the Worcester county range exhibit one system; the branch of this latter range, which extends into Middlesex county, belongs to a second without much doubt: that portion of it in the southeast part of Worcester county and in Rhode Island seems to belong to a third, and perhaps the New Bedford gneiss to a fourth. But more of this hereafter.

Hoosic Mountain Range.

	Direction.	Dip.
Cheshire, east part,	N. and S.	20° to 30° E.
Windsor to north part of Peru,	N. and S.	East.
Chester to Becket,	N. and S.	80° to 90° E.
Colebrook, Ct. to West Granville,	N. and S.	nearly 90° E.
Whitingham, Vt.	N. and S.	30° W.
Wilmington, Vt.	N. 30° E.	30° to 70° W.
do. to Somerset,	N. and S.	West, large.
Buckland,	N. and S.	10° to 20° E.,& 10° to 20° W. the latter rather predominating.

Range West of Worcester Valley.

	Direction.	Dip.
Brimfield,	N. and S.	45° W.
do. to Sturbridge,	N. and S.	20° to 80° W.
Sturbridge to Charlton,	N. and S.	45° W.
Monson to Sturbridge through Wales and Holland,	N. and S.	45° to 70° W.
Plumbago Mine, Sturbridge,	N. 30° E.	60° to 70° N. W.
Sturbridge through Southbridge to Dudley, the dip gradually decreasing,	N. and S.	60° to 25° W.
Oxford, west part,	N. and S.	10° E: usually west, and large.
Charlton to Brookfield,	N. and S.	20° to 40° E.
Western,	N. and S.	nearly 20° a little S. W.
Enfield,	N. and S.	90° nearly.

	Direction.	Dip.
Enfield to Amherst, - -	N. and S.	10° to 30° E.
Spencer, centre, - - -	N. and S.	West, small.
do. two miles east, - -	N. and S.	20° E.
Hardwick, - - -	N. and S.	20° to 30° W.
do. to Spencer, - -	N. and S.	20° W.
New Braintree, - -	N. and S.	20° to 30° W.
Ware, - - - - -	N. and S.	20° W.
Leicester towards Worcester,	N. and S.	West, small.
Pelham, west part, - -	N. and S.	20° to 30° W.
do. north part, - - -	N. and S.	15° to 20° E.
do. to Prescott, - -	N. and S.	20° to 30° E.
Shutesbury, - - -	N. and S.	45° to 90° E.
do. Lock's Pond, -	N.W. & S.E.	45° N. E.
Leverett, north part, - -	N.W. & S.E.	0° to 45° N. E.
Petersham, - - - - -	N. and S.	40° to 50° W.
Hubardston, - - -	N. and S.	30° W.
Rutland, - - - - -	N. and S.	E. very small.
Princeton, embracing Wachusett,	N. and S.	10° to 20° E.
do. towards Sterling, -	N. and S.	nearly horizontal.
New Salem to Templeton, -	N. and S.	nearly 90°.
Warwick, - - - -	between N.E. and North,	Easterly.
Warwick to Royalton, - -	N. and S.	60° to 80° E.
Winchendon, west part, to Ashburnham, - - -	N. and S.	West, various.
Ashburnham to Fitchburg, -	N. and S.	West, small.
Townsend to Rindge, N. H.	N. 30° E.	10° to 25° N.W.
Rindge, N. H., west part, -	N. and S.	30° to 40° W.
Winchester, N. H. towards Northfield, - -	N. and S.	20° to 30° E.

Range East of Worcester Valley: North part of the Range.

	Direction.	Dip.
Bolton, - - - -	N.E. and S.W.	60° to 70° N.W.
Boxborough, limestone quarry,	N.E. and S.W.	60° to 70° N.W.
do. west part, -	N.E. and S.W.	90°.
Carlisle, - - -	N.E. and S.W.	60° to 90° N.W.
Chelmsford, limestone quarry,	N.E. and S.W.	70° to 80° N.W.
Worcester to Berlin, - -	N.E. and S.W.	20° to 90° N.W.?
Concord, - - - -	nearly N. and South.	nearly 90° W.
Worcester, southeast part, -	N. several degrees E.	70° to 80° W.

South part of the Range.

	Direction.	Dip.
Worcester to Grafton,	S. several degrees W.	45° to 90° W.
Grafton to Upton,	S.E. and N.W.	N. E. small.
Mendon,	S.E. and N.W.	20° to 30° N. E.
Douglass,	S.E. and N.W.	25° to 30° N. E.
Westborough to Hopkinton Springs,	S.E. and N.W.	30° N. E.
Uxbridge,	E. and W. to S.E. and N.W.	25° N. and N.E.
Sutton,	E. and W.	30° to 35° N.
do. Purgatory,	S.E. and N.W.	25° N. E.
Burrillville and Smithfield, west part,	nearly E. and West.	25° to 30° N.

New Bedford Gneiss.

	Direction.	Dip.
New Bedford, (town,)	E. 20° N.	55° N. W.
do. Palmer's Island,	E. and W.	35° N.
Rochester,	E. and W.	35° N.
Little Compton, R. I.	N. E. and S.W.	35° S. E.

The greatest irregularity in the dip, as shown in the preceding table, exists in the gneiss in the western part of Worcester county. Yet the direction is pretty uniform, being usually north and south. And in respect to the dip, I think it obvious that a westerly dip predominates, being rather largest towards the western side of the range. Thus it is represented on Plates XVII. and XVIII. From those sectional views, it will be seen that this westerly dip is most uniform across the southern part of the range. In the central section, the dip becomes east towards the western part, and still more so in the most northerly section.

The smallness of this dip in many places is another striking circumstance in this range. If we have any rock that would be selected for the oldest described by geologists, it is this gneiss; and hence we see how deceptive was the old rule, which taught us that the relative ages of rocks might be determined by their dip.

Mineral Contents.

In some parts of the world gneiss is remarkable as the repository of a number of the precious stones. In Ceylon, for instance, where gneiss is the prevailing rock, it contains of the quartz family, rock crystal, amethyst, rose quartz, cat's eye, prase and hyalite; also topaz, schorl, pyrope, cinnamon stone, zircon, spinelle, sapphire and corundum.* Hitherto the gneiss of Massachusetts has not yielded so rich a supply. But it affords enough of the same minerals, to prove a strong analogy between the causes that produced these deposits in parts of the globe so widely separated. Especially will this be true, if we regard the limestone beds in the northeast branch of the Worcester gneiss range, as a part of this formation; and this is certainly reasonable. For in these beds have been found spinelle, a garnet which is probably cinnamon stone, asparagus stone, nephrite, and precious serpentine; and the following statement will show that several others of the Ceylon minerals have also been found in the gneiss itself.

By far the most important mineral hitherto found in our gneiss, is graphite. As described in the first part of my Report, its most important locality is in Sturbridge. It occurs in other places, however, as in North Brookfield, in Brimfield, in Hinsdale and New Marlborough; though I am not sure that in the two last named localities, the gangue is gneiss. The plumbago in Sturbridge, which is situated only two miles north of the Connecticut line, and near the western line of the town, has been explored in some places to the depth of 60 or 70 feet. I have already described it so fully as to render it necessary to add only a few remarks respecting its geological situation and mineralogical characters and associations. It is most decidedly a bed in a dark colored gneiss, which here dips from 60° to 70° west and runs N. 30° East, and S. 30° West. In immediate contact with the gneiss, we find frequently lamellar brownish hornblende, which is also disseminated to a considerable extent in the gneiss.

The lusture of this plumbago is highly metallic. Its structure is between scaly and fine granular. Sometimes, however, there is an obvious approximation to distinct crystals: though mineralogists are not agreed that this substance has ever been found in such a state. Judging however, from specimen, No. 1075 and from what the workmen told me, I suspect that if crystalized graphite occurs any where, it may be found at Sturbridge.

There is another variety found at this locality, which is distinctly fibrous: the fibres being from one to two inches long. On examination these fibres are found to be composed of distinct lamellae, which are sometimes so bent as to give the mass a fibrous appearance; as happens in certain varieties of mica slate: but more commonly these lamellae actually separate longitudinally into very narrow prisms, like prismatic mica. (No. 1074.)

At this mine I noticed phosphate of lime in small quantity. At the most southerly excavation, also, I noticed hydrate of iron, in a cross fissure in the gneiss, and forming with the ingredients of the rock a brecciated mixture. Vegetable relics are sometimes seen enveloped in the mass. Half a mile north of the meeting house in North Brookfield, I notice a similar breccia, forming a bed in gneiss a foot or two in thickness: though here I saw no vegetable remains.

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* Geological Transactions, vol. 5. p. 318.

In both these cases, I think we must regard this iron ore as having been infiltrated into cavities in the gneiss, at a recent date; and therefore, in fact, as an alluvial deposit; although at Brookfield the iron forms a distinct bed in the gniess. But the rock contains abundance of decomposing sulphate of iron, which, as we have already seen produces bog iron of exactly the same aspect as that above described; and it is not impossible that from this cause a cavity in the rock that was originally small, might have been much enlarged; while the exfoliated fragments would go to make up the brecciated mass above described.

After what I have said under graywacke and mica slate, in respect to the origin of anthracite and plumbago, it will be repetitious to add any thing farther on this subject. It may be that I am too much captivated with the beautiful simplicity of the principle, which refers every variety of peat, lignite, bituminous and anasphaltic coal, and plumbago, to a vegetable origin. But at present, I must regard that opinion as far more probable than any other.

It will be well for observers to bear in mind a remark of Dr. Davy relating especially to the gneiss of Ceylon. 'It is worthy of remark,' says he, 'that graphite is generally found in company with gems. I have had so often occasion to make the observation that I now never see the former without supposing the presence of the latter.'*

A mineral occurring in our gneiss, and often confounded with graphite, is the sulphuret of molybdenum. I have noticed this in Brimfield in scales; and in the north part of Shutesbury, a little east of Locke's Pond, it has been found in hexagonal plates nearly an inch in diameter.

The mineral found in our gneiss, which next to graphite will excite most interest in an economical point of view, is the native alum mentioned in a postcript to the first edition of the first part of my Report. It is found efflorescing on that schistose variety of gneiss, which is passing into mica slate. There is mixed with it more or less of sulphate of iron, and both minerals proceed from the decomposition of iron pyrites, and probably feldspar. This last mineral contains, as is well known, a considerable quantity of potassa; and I can imagine no other source from whence this essential ingredient of alum should be obtained. Nor will any one doubt, who has seen how thorough is often the decomposition of the gneiss that contains pyrites, that this potassa might be separated. I am not aware that alum has been heretofore found in gneiss: but since this rock does contain so much potassa, and if it can be thus separated from the feldspar, why may not our gneiss prove a very prolific source of alum? I do not know that any special efforts have been made to ascertain whether it can be procured in much quantity from the rock in Leominster: but recently I have received a specimen from Barre, and it occurs also in Ware. And I can have no doubt that any part of the gneiss range, where pyrites is decomposing, will produce it. It may be hoped that a fair trial will erelong be made to obtain this substance. This is not the proper place to make suggestions as to the best mode of proceeding. Suffice it to say, that no effort should be made on a large scale, without consulting some practical chemist.

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*Geological Trans. vol. 5. p. 323.

The Worcester county gneiss ranges contain in many places, an abundance of blood red, often ruby red, and translucent garnets. Often they are extremely minute and perfectly crystalized; but sometimes, as in Brookfield, they are more than half an inch in diameter, and the crystal is very imperfect. At length it becomes perfect pyrope. And it is a curious fact that there is a strip of gneiss, (sometimes approximating to mica slate,) extending from Norwich in Connecticut, half across, and probably entirely across Massachusetts, which abounds in this mineral. This strip passes along the western part of Wales, Brimfield, Ware, &c. In no place, however, except Brimfield, is the color of this garnet so delicate as in Norwich, Ct., where it is found in mica slate.

The foliated masses of feldspar in the porphyritic gneiss passing through Brimfield, Ware, &c., are frequently a delicate adularia. In Southbridge, in a decomposing ledge of gneiss, near the centre of the place, the feldspar is of a delicate green, yet almost transparent; being quite elegant when polished. (No. 1086.) In cavities in the gneiss in Boxborough, I found distinct, yet not handsome crystals of feldspar. The same occur with actynolite, augite, and sphene, in Pelham.

Common schorl is frequently seen in the gneiss of Massachusetts, as in Athol, Pelham, and New Braintree. In the latter place, the crystals have distinct acuminations. Often, as in Athol and Pelham, epidote, sometimes in crystals, is associated with the schorl.

In the New Bedford gneiss, as I was informed by T. A. Greene, Esq., epidote occurs along with the red oxide of titanium. In the gneiss in Pelham, I have noticed some crystals of sphene as just mentioned. But the sphene which I lately found in the augitic gneiss in the east part of Lee, is finer than any I have met with in New England. (No. 1091.) The crsytals are very oblique rhombic prisms, variously modified at their extremities; resembling those represented on Plate XII, figures 47, 48, and 49, of Beudant's Mineralogy.

It has already been repeatedly stated, that the sulphuret of iron is one of the most abundant of the minerals in the gneiss of Worcester county. In Hubbardston, as I have mentioned elsewhere, this ore is wrought for the preparation of copperas. In the gangue of the ore occurs a mineral which exceeding resembles peliom, though it may be blue quartz. It deserves farther examination.

Magnetic oxide of iron is sometimes met with in small disseminated masses in gneiss, as in Athol and Shelburne.

Arsenical sulphuret of iron is said to occur in Leicester in gneiss.

In Pelham we meet in this rock, with well characterised specimens of anthophyllite.

In that town, also, is a great abundance of finely crystalized quartz. Some of the crystals are quite delicate. They are commonly limpid, though sometimes of a light brown color, and sometimes of a fine topaz yellow, being genuine yellow quartz. Rarely are they amethystine. Not unfrequently large cavities are drusy, and present fine specimens. The crystals vary in size, from two inches in diameter to the fineness of a sewing needle. It is not easy to ascertain the precise situation of this quartz in the gneiss; since it is seen only in loose masses scattered over several acres. Probably, however, it constitutes a vein. I observed no metallic substance in it, except a little sulphuret of iron.

Associated with this quartz are found beautiful specimens of mamillary chalcedony. (No. 1002.) Rarely it is of a milk white color; but commonly of a delicate blue. Sometimes it may be seen investing distinct crystals of quartz, thus showing its origin to be watery infiltration beyond all question.

It has already been mentioned that steatite and serpentine occur in beds in our gneiss. In Milbury, a variety of the former has been found, which has been called *vermiculite*, on account of its singular property of shooting forth vermiform masses when exposed to heat: thus giving to the specimens, when in the fire, the appearance of worms in motion.

I have seen a specimen of gray copper from Brimfield; and from the geological constitution of that region, I infer that it originated from gneiss.

In Washington, Ct., the gneiss contains mesotype and stilbite; and at Bellows Falls, on the Vermont shore, a radiated mineral of the zeolite family, with another in small and distinct crystals, which I shall describe under greenstone, as a new species, by the name of *Lincolnite.*

Theoretical Considerations.

Since gneiss is composed of the same simple minerals as granite, it is natural to infer that both must have had a similar origin. And especially are we led to such a conclusion, when we see in granitic gneiss a gradual passage from the one rock into the other. That granite has resulted from heat, instead of aqueous deposition, seems to me to be so well established, that the opinion that imputes to it such an origin, ought no longer to be regarded as hypothesis, but as legitimate theory. Thus it is regarded by nearly all the ablest geologists of Europe; and in the proper place I hope to show that our granite presents equally strong evidence of such an origin as that on the eastern continent. At present, I shall assume that theory to be the correct one, which supposes granite to have resulted from the melting down of other rocks; the fused mass having cooled so slowly as to present a confused crystalization. It is at least a probable supposition, that the rock out of which it was produced, was of mechanical origin, and consequently stratified. Now if the central heat was not sufficient entirely to melt this stratified rock, yet it would be powerfully affected a considerable distance upward from the molten mass. The layers in immediate contact with the melted portion, would be partially fused, and hence give origin to granitic gneiss. Another portion might be converted into porphyritic gneiss; another into lamellar; another into schistose; &c. All the rock we may suppose so near the fluid granite, and so long in contact with it, before cooling, that a crystalline would succeed to a mechanical arrangement of all its ingredients, without losing the stratified disposition.

The facility with which this hypothesis explains the graduation of gneiss into granite, and the crystalline and especially the porphyritic structure of the gneiss, is the principal argument in its support. Such effects we know might have resulted from heat: but they could not have resulted from watery solution.

As to the mechanical rock from which gneiss was produced, according to this theory, we are left only to conjecture. Most probably it was a coarse micaceous sandstone, which resulted from the disintegration of granite, previously existing. When hornblende slate alternates with the gneiss, we have only to suppose that formerly clay slate was interstratified with the sandstone: and where there is an interlamination of mica slate and gneiss, we have only to suppose that in some portions of the sedimentary rock, the necessary ingredients for the production of feldspar were wanting. In the same manner, the quartz rock associated with the gneiss, might have proceeded from a sandstone composed chiefly of siliceous sand.

According to this view of the subject, granite, and perhaps other primary rocks, must have existed anterior to those which now form the crust of the globe; and from the detritus of which, the existing primary rocks were produced; being subsequently indurated and crystalized by a new eruption of granite and other unstratified rocks. Thus we trace a number of successive epochs of renewal and destruction, before the earth assumed its present form: and now we see the process of destruction going forward. To these changes the mathematician* who first developed the fundamental principles of this theory saw no marks of a commencement,—no prospect of an end; and hence he has been supposed to defend the hypothesis of the world's eternity, and to exclude a Deity from its creation and government. But surely his own theory did not teach him that the earth had existed in more than two states anterior to the present; viz. the state that preceded the existence of our present primary strata, and that which included these only. And had he been acquainted with the history of organic remains, as the subject is now understood, he might have known that there is no proof of more than five or six extinctions of animals and plants antecedent to the creation of the present races; and still farther, he might have known that each successive creation exhibited a greater degree of perfection in animal natures; thus proving a progressive state of things: which implies a commencement. And the whole history of the rock strata shows a corresponding improvement in the state of the globe, pointing us back to an original beginning. Further, had this philosopher been as well acquainted with the chemistry of nature as with her mathematics, he must have known, that an intensely heated globe could not have existed eternally in that state; and that as there must have been a period when it began, so there will be a period when it will cease to radiate heat; and, therefore, the fundamental principle of his theory should have taught him, that probably the world had a beginning, and will have an end. Indeed if I understand geology aright, so far from teaching the eternity of the world, it proves more directly than any other science can, that its revolutions and races of inhabitants had a commencement, and that it contains within itself the chemical energies, which need only to be set at liberty by the will of their Creator, to accomplish its destruction. Because this science teaches that the revolutions of nature have occupied immense periods of time, it does not, therefore, teach that they form an eternal series. It only enlarges our conceptions of the Deity; and when men shall cease to regard geology with jealousy and narrow-minded prejudices, they will find that it opens fields of research and contemplation as wide and as grand as astronomy itself.

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* Dr. Hutton.

UNSTRATIFIED ROCKS.

I have already described several rocks, (ex. gr. limestone, serpentine, and one or two varieties of hornblende slate,) as sometimes stratified and sometimes unstratified. But the rocks which I include under the present division, are never stratified in the proper sense of that term. They are, indeed sometimes divided into parallel masses : but in such cases this peculiar form seems to result from that kind of crystalline arrangement called the concretionary structure. The question so long agitated, whether these rocks, particularly granite, are stratified, seems at last to be satisfactorily settled in the negative. This character, therefore, may with propriety be employed to designate one of the great classes of rocks.

Unstratified rocks occupy but a small part of the surface of any country. In Great Britian Macculloch says they 'do not cover a thousandth part of the superficies of the island.' In Massachusetts however, as may be seen by the map, they form at least a quarter part of the surface.

These rocks occur in three modes: 1. In irregular protruding masses, intruded in almost every manner among the stratified rocks, and enlarging downwards indefinitely: 2. In the form of veins of various sizes, and often ramified: 3. As overlying masses. It has been stated, also, that they exist interstratified with other rocks: but an examination of all such cases has shown, that such interlaminated masses are always connected with an unstratified mass, and are merely veins, which for a time coincide in direction with the strata.

One cannot examine the unstratified rocks with attention, without perceiving that their mode of production must have been in some respects different from that of the stratified rocks. Not long since the general opinion was, that they originated from the crystalization of their ingredients dissolved in water. At this day the belief in their igneous origin has become nearly as universal. In regard to the trap rocks, indeed, this opinion is almost unanimous. Why there should be any more hesitation in assigning a similar origin to granite, I confess myself unable to imagine. I should almost as soon deny that the red rays of the spectrum proceed from the sun, after admitting that the six other colors were produced by that luminary. I am constrained thus early to express my conviction of the igneous origin of all the unstratified rocks : for I have found that opinion marvelously to simplify the history of these rocks ; and to clear up many difficulties inexplicable on any other theory. To regard these rocks as they occur in the primary, secondary and tertiary classes, as independent of one another, and of the same age of the formations in which they occur, and thus to describe them as primary, transition, secondary, &c. produces in this part of geology a perfect chaos. But to regard them all as merely varieties of the same melted mixture, whose peculiarities resulted from the modes in which they were cooled and crystalized, and intruded among the stratified rocks, does certainly relieve the mind of a host of doubts and difficulties, and render the history of these varieties comparatively easy, whether the theory be true or false. On this supposition we are no longer surprised to find it impossible to draw any definite line between the different varieties, nor to find them all united in the same mountain mass.

It must not however, be understood that this view of the subject implies that all the unstratified rocks are of the same age. For in this respect there is evidence of nearly as great diversity as exists among the stratified rocks. And their intrusion among the stratified rocks affords an important clue for determining their relative ages. It is obvious, however, that the intrusion of the former among the strata of the latter, only proves that the unstratified rock was formed posterior to the stratified one. And on this principle it has been shown, that granite has been protruded even since the deposition of the chalk: while basalt has cut through even the supercretaceous rocks; and finally, the products of existing volcanoes overspread diluvium and alluvium.

So well satisfied am I of the correctness of these views respecting the unstratified rocks, that I have been strongly tempted, according to the suggestion of Dr. Macculloch, to treat of all those that occur in Massachusetts as a single family; being convinced with him, that 'geological philosophy must adopt this (proposal) sooner or later.' But if that geologist shrunk from taking the lead in such an innovation, well may I. The members of the unstratified class in Massachusetts are not numerous; and I have concluded to treat of them all under four divisions, viz. greenstone, porphyry, sienite, and granite.

There would be some advantages in treating of these rocks in an ascending, instead of a descending order: that is, in beginning with granite, taking sienite next, porphyry next, and greenstone last. For this is the order in which in general they seem to have been produced. But for the sake of uniformity, and to secure some other advantages, I shall invert this order.

A few words may be needful in this place, in respect to the manner in which these rocks are represented on the map. From the intricate manner in which the greenstone, sienite, and granite are mixed together, in the vicinity of Boston, I found it impossible to give them precisely their true relative space in the delineation.

I therefore colored the whole space occupied by them all, as granite; and then, having observed that as a general fact the greenstone was first met with, on lines radiating from Boston, then porphyry and sienite, and lastly granite, I represented these several rocks as occupying spaces somewhat in the form of concentric bands. Wherever I observed these rocks intermingled, however, I have endeavored to represent their mixture by scattering dots and crosses somewhat promiscuously in the region. This method of course can give only an approximation to the truth. In the valley of the Connecticut, these rocks are scarcely ever so confusedly mixed together; and, therefore, it is only in the eastern and northeastern parts of the State that such a course has been adopted. The porphyry forms only two ranges, which are distinct; the one on the north, and the other to the south of Boston, except that a narrow strip of compact feldspar,—the base of porphyry,—is marked in the northern part of Essex County. Porphyry, however, passes by insensible gradations into sienite, but the change commonly takes place in a vertical and not in a horizontal direction.

15. GREENSTONE.

The most approved definition of this rock makes it to consist of hornblende with compact and common feldspar: some add clinkstone also: but as this substance does not occur in this part of our country, it is of no importance in the present instance, whether it be added or not. A mixture of hornblende and feldspar, the former in much the largest proportion, and both of the minerals exhibiting but little of a crystalline structure, constitutes the great mass of the trap rocks of Massachusetts. Other varieties do indeed occur, composed of different ingredients: but as these are found in such small quantity, and are obviously accidental varieties, I have thought it most judicious to describe them all under the term greenstone. Such a liberty I have frequently taken in the case of the stratified rocks; and I think it still less objectionable in the case of the unstratified; because there is much more diversity of opinion among geologists as to the ingredients that compose the latter. These ingredients are often so little crystalline, as to be exceedingly obscure in their characters; and it is, therefore, no wonder that such diversity exists even in the statements of the ablest writers. Especially is this not surprising, when we recollect, that until recently, it was thought essential to a good description of these rocks, that the observer should be able to prove that they belonged either to the primitive, transition, or secondary class of the stratified rocks. It was bad enough to be obliged to stretch the stratified rocks upon this Procrustean bed, although here these artificial divisions had some appearance of naturalness; but in the unstratified rocks, no facts could be found on which to base such an arrangement; and, therefore, imagination must supply the necessary characters. The consequence was, that minute and ever varying mineralogical characters in the trap rocks were studied with scrupulous exactness; while their geological position and chemical and mechanical influence on other rocks, were scarcely noticed.

Mineralogical Characters.

1. *Hornblende and Feldspar:* the mixture more or less granular. Commonly the ingredients are so fine that they are with some difficulty discerned by the naked eye. Hence it is not easy to determine always whether the feldspar is compact or foliated. Frequently I believe, however, that both varieties will be found, and that often in the same specimen. The crystalline structure of the hornblende is usually very indistinct. In the eastern part of the State, however, where this rock is associated with sienite, the two ingredients are often very distinct and the texture crystalline. A variety occurs on Mount Holyoke and in West Springfield, in which the ingredients are very coarse, and the feldspar, which is foliated, is of so dark a color as with difficulty to be distinguished from the hornblende. (Nos. 1127, 1128.) The feldspar is arranged in stripes, like a ribbon, as in the sienite near Boston.

The compound that has now been described, constitutes the principal part of the greenstone dikes, ridges, and hummocks, in Massachusetts. (Nos. 1106 to 1135.) The same compound occurs also in other forms, as will be seen in the sequel.

2. *Columnar.* This differs from the preceding variety only in form: for its composition is almost uniformly the same. Nearly all the greenstone in the valley of the Connecticut exhibits more or less of a *conatus* at a columnar structure, except the tufaceous variety. Yet it is the finely granular variety, that exhibits the most perfect forms. A similar conatus appears in some of the beds of greenstone in the eastern part of the State, especially in Charlestown: but these columnar masses are so imperfect, compared with some of those in the Connecticut valley, that I shall limit my remarks entirely to the greenstone occurring in that valley: and as it is more convenient, I shall in this place give the topography of the variety under consideration.

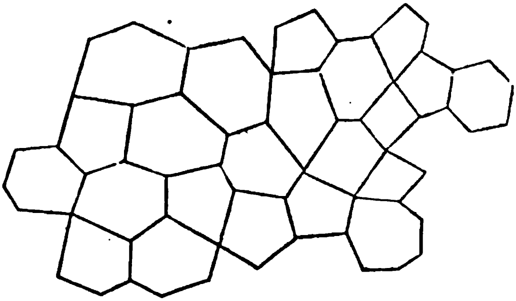
Nearly all the ridges of greenstone in the valley of the Connecticut, (for a reason that will appear in the sequel,) present on their western sides, a nearly perpendicular face. Usually, however, the angular fragments that have fallen from these precipices, have accumulated at the bottom, so as to form a steep talus, reaching half or two thirds the distance to the summit; and sometimes entirely to the top. Where the rock appears in the face of the cliff, it is almost always more or less columnar; sometimes as much as 30 or 40 feet in height. In some cases one set of columns is separated from another set, above or below, by a stratum or mass of trap tuff.

There are, however, only a few places where these columns are very perfect. Along the west side of the greenstone ridge that forms the eastern part of Deerfield mountain, in several places, about a mile east of the village, they exhibit great regularity. Usually their diameter here,—and the same remark will apply to every other locality,—is between two and three feet; rarely as small as one foot; and the number of their sides between four and six. They are sometimes distinctly articulated; the joints varying from one to three or four feet in height. The articulations are usually curved, at their ends presenting frequently a convexity on the upper side, and a concavity on the lower. The breadth of the sides is considerably unequal; and with this exception, perhaps, these columns might compare in regularity with those of basalt from Ireland.

I have already given a general description, in the second part of my Report, of an exhibition of greenstone columns towards the southern extremity of Holyoke, in the western face of the hill. At that place we see but little of articulation: but a most remarkable disintegration, or rather exfoliation, is there constantly going forward; as the immense number of fragments at the base of the cliff testifies. The pieces that split or scale off, are of almost every shape; but they are commonly rather thin, sometimes in curved laminae an inch or two thick. When the lower part of a column begins thus to scale off, the fissures take such a direction as to leave the under side of the column, still projecting from the precipice, in the form of a hemisphere, or more commonly in the form of a paraboloid; and not unfrequently of a lenticular form. And in one spot at least, the upper portion of two or three rows of columns is suspended over the head of the observer, appearing like numerous iron kettles, not less than three feet in diameter, hanging from the rock. This is certainly one of the most singular natural objects that I have ever met with; nor can one feel at perfect ease beneath such a piazza, when he sees by how feeble a hold these masses of immense weight are sustained; and how instantly one of them falling would grind him to powder.

I have been at a loss to decide, whether the exfoliation which is exhibited at this spot, takes place according to an original structure of the rock, or is produced by the natural action of the disintegrating agents; such as air, moisture, heat, and cold, upon rocks of a peculiar form. I can hardly admit the latter supposition; when, on breaking the fragments, they are found, except for a mere line at the surface, to be so entirely unchanged. Yet this curved form of exfoliation is not the only one exhibited on this greenstone range. More frequently the columns split longitudinally, into somewhat irregular pieces, from one to six or more inches in diameter. All along the western side of Mount Tom, examples of this kind may be seen; and the quantity of fragments of this sort, accumulated at the base of this mountain, is immense. Sometimes these fragments are very regular in their forms; producing prisms of three, four, five, &c, sides, and three to six inches in diameter. (Nos. 1136, 1137, 1138.) Again, as at Titan's Pier, described in the second part of my Report, concave layers of the rock (No. 1139) cleave off from the upper extremity. A joint of this description will sometimes contain several quarts of water; and I have seen one of them standing by a farmer's well, which was used as a substitute for a wash-bowl! Upon the whole, I am of opinion that the form of these exfoliations depends upon original structure, which the disintegrating agents above mentioned reveal, but do not create.

I know of no spot where so good a view of the ends of these greenstone columns can be obtained, as at Titan's Pier above mentioned. They are exhibited to the best advantage on the west side of the ridge, where it passes under the river: and at low water, we can see the ends of the columns forming the bottom of the river, as far as the eye can reach. The following sketch represents above twenty of these columns, as they present themselves at low water, and close to the water, at the spot just mentioned. The sides were not measured except by the eye, and I am confident that there is quite as much, probably more regularity in the columns themselves, than in the drawing. The sides, it will be seen, vary from four to six. The upper ends of these columns are considerably convex: whereas only one rod farther from the water, as already mentioned, they are decidedly concave. And although it is possible that in the first case the form might have resulted from the action of the river, yet from all that I have seen, I much doubt whether the upper or lower end is uniformly convex or concave.



Ends of Greenstone Columns at Titan's Pier.

Both at Deerfield and at Holyoke, one sometimes meets with columns that are considerably curved. In general they are not perpendicular to the horizon, but lean from 10° to 30° towards the east. Hence they stand about perpendicular to the strata of sandstone beneath.

The two varieties that have now been described comprehend the greater part of the *grunstein* of Werner, the *diorite* of Hauy, and the *diabase* of Al. Brongniart. These writers, however, mention only compact feldspar as an ingredient: but Dr. Macculloch very properly adds common feldspar.

3. *Compact.* In this variety, which is almost entirely homogeneous and finely granular in its texture, the different ingredients cannot be distinguished. In some cases it is probably only indurated clay, or wacke, with some dark coloring matter: in other cases, it may be hornblende and feldspar, completely melted together. The aspect of the rock approaches closely to some varieties of basalt; but it is doubtful whether we have any trap rock in this part of America, which was produced at the same epoch, or is composed of precisely the same mixture, as the European basalt. The variety under consideration occurs generally in the form of veins; as at Nahant, &c. (Nos. 1140 to 1143.)

4. *Chiefly Greenish Compact Feldspar?* This is a beautiful rock; but its characters are very obscure. Perhaps it ought to be described under porphyry: but its great resemblance to the traps, has led me to place it here. It occurs in Essex county along with sienite, common greenstone, &c. (Nos. 1144 to 1147.)

5. *Indurated Clay.* This variety is of limited extent; occurring only at the junction of greenstone and shale; as at Titan's Pier. In aspect it approaches to hornstone; being of a light gray color. In the same mass with this rock, we usually find angular pieces of compact trap: so that in fact it might have been described under *trap tufa.* (Nos. 1148 to 1150.)

6. *Hornblende, Augite? and Feldspar.* The hornblende in this compound is in crystalline fragments; and the mineral which I suspect to be augite, is of a greenish aspect, but scarcely crystalline. The feldspar is sometimes foliated and in small quantity. It occurs only at Nahant, a little distance northwest of the Hotel: and the most remarkable circumstance in relation to it, is its apparent regular stratification. This is the only instance that I know of in Massachusetts where a trap rock exhibits those parallel divisions. I do not, however, regard them as real strata, for reasons that will be hereafter mentioned. (Nos. 1152 to 1155.)

I should not have noticed the above as a distinct variety, had not its peculiar aspect excited the suspicion that it might be a *dolerite* of the geologists of continental Europe. I do not feel satisfied what is its real composition; and I have even had a suspicion whether it may not be the *hypersthene rock* of Macculloch.

7. *Porphyritic.* There is considerable diversity in the composition of the rocks included under this term. Their characters and situation deserve a particular notice, since they are frequently useful for ornamental purposes. (Nos. 1156 to 1164.)

On Cape Ann a variety occurs, which resembles the black porphyry of the ancients, and appears to be the *trap porphyry* of Werner, and the *melaphyre* of Al. Brongniart. I should describe it as having a base of common greenstone, with large imbedded crystals of greenish foliated feldspar. Sometimes these crystals are more than an inch in diameter. It occurs at Sandy Bay, near the village, in veins in sienite. A similar rock is found in veins at Marblehead, according to the Messrs. Danas: also in rolled masses in Dorchester, Brookline, and Roxbury. I have noticed the same rock in rolled pieces in Easton, except that the feldspathic crystals are white. (Nos. 1156, 1157.)

In Ipswich, west part, I found a rolled mass which appears to be a greenstone with numerous foliated masses of a shining black color, which I at first suspected to be feldspar: but I am satisfied that they are *Karinthin.* (No. 1159.)

A considerable part of the eastern or upper side of the greenstone in the Connecticut valley, is very different in its composition from the principal part of the ridges. The basis of the rock is wacke-like; and some of it is amygdaloidal, and some of it porphyritic. The foliated masses of feldspar, however, are so small and so numerous, that I doubt whether it might not with quite as much propriety be reckoned as common trap. I doubt whether it contains any hornblende. Its general color is gray. (Nos. 1163, 1164.)

Occasionally we meet among the greenstone of that part of the State, with other varieties that are more or less porphyritic. No. 1161, from Deerfield has a compact homogeneous base, nearly of the color of brick, with a few small imbedded crystals of feldspar. It is found in the same mass with common greenstone; but seems to have been exposed to a higher degree of heat. No. 1160, from Turner's Falls, has a variegated base, whose nature is not obvious, with crystals of feldspar.

8. *Amygdaloidal.* This structure, like the porphyritic, is found in nearly all the varieties of greenstone that have been described. The following are the most common of our amygdaloids. (Nos. 1166 to 1175.)

With a base of hornblende and feldspar: the first variety of greenstone above described. I have never seen any of this amygdaloid very regularly columnar: still it very frequently exhibits a columnar tendency. And it is a curious fact that the cavities often run lengthwise of the column, and are parallel to one another; so that the rock resembles a block of wood, which worms have bored through repeatedly in a longitudinal direction. I have observed some of these cavities a foot or two in length. (No. 1166.) On account of the compactness of this rock, these cavities are usually filled with foreign substances, such as calcareous spar, chalcedony, quartz, chabasie, Lincolnite, &c. The best spot that I know of for obtaining specimens of this rock, is one mile directly east of the academy in Deerfield.

In the same ledge, as well as in other ledges, the amygdaloid abounds in spherical or spheroidal cavities, filled with quartz or calcareous spar.

What particular causes produced these different forms in the cavities, it may not in the present state of knowledge be possible satisfactorily to ascertain. That they were all produced by an elastic fluid, while yet the rock was in a plastic state, seems now generally admitted. Must not the different forms which they have assumed, be imputed to inequality of pressure? And yet the air vesicles in a mass of ice exhibit the same variety of shapes, some of them being cylindrical, some spheroidal, and some spherical: nor can we in this case impute their form to inequality of pressure. But whatever the cause be, as in both instances the effect results from refrigeration, may it not be the same?

The most usual amygdaloid in the Connecticut valley has a base which appears to be wacke. It occupies, as already remarked, the easterly part of the ridges wherever I have examined them. For the most part, it is liable to partial decomposition to a considerable depth from the surface, and the imbedded minerals have entirely disappeared. When they still remain, calcareous spar is the most common. Not unfrequently, however, foliated chlorite occupies most of the cavities; and sometimes, as at Turner's Falls, they are filled with chlorophoeite. Green earth, or earthy chlorite, is still more frequently present. Sometimes the base is of a reddish hue; but commonly of an earthy gray. In such cases the rock exceedingly resembles a toad in appearance, and is probably similar to, if not identical with the toadstone of some of the English geologists. When the cavities are empty, the rock can hardly be distinguished from some recent lavas. (Nos. 1170 to 1174.)

All these varieties with a wacke-like base, exhale a strong argillaceous odour when breathed upon.

The greenstone in the eastern part of the State is rarely amygdaloidal.

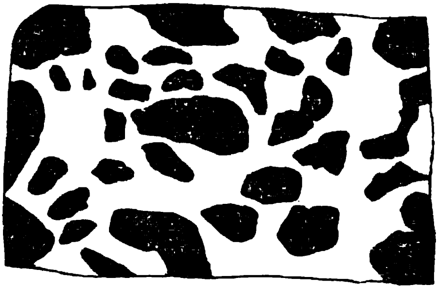
9. *Concreted.* The argillaceous substance above described, as forming the base of certain amygdaloids, sometimes contains numerous distinct concretions of the same substance, apparently more indurated. They are generally spheroidal; and the concentric crusts not more than a line in thickness. Sometimes I have observed the central nucleus to consist of a rounded mass of amygdaloid enveloped by coats of indurated clay or wacke. The diameter of these concretions is sometimes six or eight inches: but usually not more than two or three. They sometimes occur imbedded in the next variety to be described. Their most abundant localities, which I have noticed in Massachusetts, are in Deerfield, east of the village, and on Mount Holyoke, near the road from Amherst to Granby. (Nos. 1176, 1177.)

10. *Tufaceous.* This embraces all those rocks that are composed of fragments of any of the varieties of greenstone that have been described; whether these fragments are angular or rounded; united by 'trap sand,' or the same materials in a comminuted state. Sometimes, however, the rock consists of angular fragments of greenstone, cemented by calcareous spar. In this case it is obvious that the spar was introduced by watery infiltration, after the fragments had been piled together. In other cases, it is equally obvious that the fragments have been melted together: for we distinguish the different materials of which they consist, only by the different colors; it being no easier to separate the rock along the line where the fragments unite, than in any other direction: and I do not suppose it possible to unite fragments so firmly except by fusion. (Nos. 1178 to 1186.)

Topography of the Greenstone.

The parts of the State in which greenstone occurs in sufficient quantity to be noticed on a Map, are only two. In the eastern and northeastern part of the State, it will be seen that there are extensive ranges. As we pass beyond the graywacke and argillaceous slate that encircle Boston on the north, west, and south, we usually find greenstone to be the predominant rock. Even on the south, in Milton, &c. where porphyry is represented on the Map as succeeding to the graywacke and clay slate, we usually meet with narrow masses of greenstone, probably in some cases interposed among the layers of slate. On the north of Boston, in the slate of Charlestown particularly, such masses or beds of greenstone are common; and some of them so large that I have noted two of them on the Map. In this slate also, as well as in the graywacke in other places, (as at Roxbury,) the greenstone is found in veins. At Nahant they are sometimes forty feet thick, in argillaceous slate and sienite.

If we proceed from Boston, after striking the deposit of greenstone aboved named, we shall soon find that it is passing into sienite, and mixed with sienite in almost every conceivable mode. In one place the greenstone seems to form a distinct vein in the sienite, the two rocks being well defined at their line of junction. In another place, the sienite seems to form veins in the greenstone; although in such cases it is no easy matter to determine which rock should have the posteriority: But from the general fact, which I think obvious in this region, that the greenstone has been produced subsequently to the sienite, I think we should be cautious in reversing this order without good evidence. In some cases, however, we meet with a reddish sienite containing numerous and sometimes large angular and rounded fragments of greenstone. I give a rough sketch below, of one of these cases, which I observed in Marblehead, a little west of the town. In this case the base of the rock is rather a red granite than sienite, being entirely destitute of hornblende.



Granite and Greenstone: Marblehead.

Instances similar to this are to be seen every where in the region under consideration. And they certainly appear as if the greenstone had been partially melted down in the granite; though the heat was not great enough to complete the fusion. Or rather, may it not be probable, that the perfect fusion of the rock out of which those unstratified ones were produced, gave rise to the granite: while those portions that were not so entirely fused as to admit of entirely new and perfect combinations and crystallizations, might have formed those portions of the rock which I call greenstone, although some of it might as well perhaps be denominated sienite. I am aware that it is not yet well ascertained, how the same materials should at one time have produced granite, at another sienite, at another porphyry, and at another greenstone. But some other facts which I have noticed on this subject, and which will be detailed in speaking of granite, render it somewhat probable that the more or less perfect fusion of the materials may have been the principal cause. According to this hypothesis, we might explain how it happens that greenstone and sienite for the most part, were produced since the formation of granite. For geology furnishes abundant evidence that the temperature of the interior of the earth has been gradually sinking, since the commencement of these processes. And then again, the later any rock was erupted, the less chance it has had for undergoing a second fusion, which, it may be, is all that is neccssary to convert it into some usually described as older variety of rock. However, I will not dwell upon a suggestion that is so very hypothetical.

As we proceed farther from Boston, the sienite increases and the greenstone decreases in quantity, and we begin to find granite destitute of hornblende, which at length often becomes extremely coarse; as in Billerica, Andover, &c. The greenstone, however, occasionally appears associated with the perfect granite, as with the sienite; though I do not recollect any instance where the passage from the greenstone to the granite is gradual, as is the case between greenstone and sienite. Generally the greenstone forms veins in the granite. I have sometimes traced them not more than a foot or two wide for several rods, (as in Weymouth,) retaining their direction and width with almost mathematical exactness.

In the manner that has now been described, is the greenstone of the eastern part of the State intermingled with its unstratified associates, as the youngest member of the group. To mark out the precise limits of this rock in that section would require immense labor, both on account of the great quantity of diluvium that overlies the rocks, and the difficulty of drawing the line in all cases between greenstone and sienite. Nor, if it be correct that all these unstratified rocks are mere varieties of the same family would such a demarcation be of any great use; although I could wish to see it done; since in that way many facts might be brought to light important to geology.

Rarely does the greenstone under consideration form ridges or elevations of any considerable height. In Weston, Waltham, Lincoln, Lexington, and West Cambridge, this formation attains its greatest elevation; which is never as much as 500 feet above the ocean.

The greater part of the greenstone under consideration is exceedingly hard and compact, and the ingredients are with difficulty distinguished. When passing to sienite, however, they become coarse and highly crystalline. Very frequently the rock has a greenish aspect, from a quantity of epidote which is disseminated in it, or forms narrow veins, or a coating upon the surface. It is not common, except where it is associated with the graywacke, to see it exhibit that brown dirty aspect so common in the trap rocks of posterior date.

Occasionally we find examples of a slaty structure in this greenstone. And it must be regarded as really a slaty structure, not the result of a concretionary deposition.* For the slate generally appears to be genuine hornblende slate, sometimes rather less crystalline, however, than that rock generally is. I recollect at this moment but three places where this slaty greenstone was observed: viz. in Lincoln, on the turnpike between Andover and Boston in Stoneham, and near the line between Reading and Wilmington. In a theoretical point of view this fact seems to me important; and I shall recur to it in the sequel.

Variety No. 4. that has been described on a preceeding page, is found in connection with sienite, a mile or two north of Byfield Academy. Near the academy we find red compact feldspar: but I do not know that this is at all connected with the greenstone. On the north side of the Merrimack river, in Salisbury, opposite Newburyport, this same variety of rock occurs in juxtaposition with sienite. Its aspect not a little resembles the varioloid wacke in Saugus; and I am not without strong suspicions that it may be the same rock highly indurated. And it strengthens this suspicion to find that sometimes in Newbury it exhibits a varioloid structure.

The Map exhibits the most northerly of the greenstone ranges in the Connecticut valley with which I am acquainted; though in Vermont and New Hampshire in this valley, greenstone occurs in connection with argillaceous and mica slate; but probably this is a variety of hornblende slate. The greenstone which I am now describing, is associated with the new red sandstone; and ridges of it may be seen extending almost uninterruptedly from New Haven, Ct. to the north line of Massachusetts. The principal ridge commences with West Rock, at New Haven, and extends from thence, almost in a right line, to Mount Tom in Massachusetts. In Connecticut several other ridges and hummocks of this rock exist to the east of this principal one; as may be seen on a geological map of the Connecticut valley, which I prepared for the 6th volume of the American Journal of Science.

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*Dr. Macculloch, however, regards the slaty structure as a variety of the concretionary.

The principal greenstone ridge above noticed, crosses the Connecticut river between Holyoke and Tom, and curving towards the east, terminates in the north-west part of Belchertown. At the southern extremity of Mount Toby, however, we meet with another much more diminutive ridge, or dike of this rock, which almost coincides in direction with the meridian through Sunderland, and crossing the Connecticut river near the north line of that town, rises in Deerfield to a much greater altitude, forming the eastern half of that range of hills which occupies the eastern part of that town and Greenfield. In Deerfield the eastern side of the greenstone is very gentle in its slope, and precipitous on its west side. But in Greenfield, although the western side continues to present a mural face, its eastern side also is very steep; being washed by the waters of the Connecticut. This ridge terminates at Turner's Falls in Greenfield. Another parallel ridge commences at the same place, only a few rods distant but on the opposite side of a small river, (Fall river,) in Gill, and extends more than a mile towards the centre of that town. Beyond the extremity of this ridge, I have not found any greenstone except that which I have described as a member of the hornblende slate formation. A deposit of this, as may be seen by the map, commences in the north part of Gill, only three or four miles north of the point where the greenstone already described terminates.

The external aspect of the greenstone in the Connecticut valley, is very different from that of the same rock in the eastern part of the State. Much of the latter is of a dark color, or when examined nearer, of a green aspect, from the presence of epidote. But the former almost universally exhibits a gray or iron rust color, either from incipient decomposition, or from the presence of oxide of iron.

The most common variety of the greenstone in the Connecticut valley is a fine grained mixture of hornblende and feldspar. This is sometimes columnar, as already described. Not unfrequently too, it is amygdaloidal; though the more perfect this structure, the less perfect the columnar. Trap tuff is also much more frequent than I formerly supposed. Sometimes we find a mass of it overlaying a mass of columns; and sometimes it forms an irregular layer between the ends of successive stories of columns. A mile east of the village in Greenfield, a variety of tuff constitutes a large part of a ledge of greenstone, which in some places is more than a hundred feet high. I have observed this rock on the west side of Mount Tom, also on Holyoke, and various other places. It must be carefully distinguished from the *trap conglomerate*, that has been already described as a member of the new red sandstone formation, lying upon the eastern side of Mount Holyoke and Tom. The real trap tuff contains no fragments of sandstone;

whereas in the trap conglomerate, the sandstone usually forms the cement. But the two rocks obviously pass into each other.

The boldness and wildness of the scenery in the Connecticut valley result principally from the greenstone ridges that have been described. The summits of these are often very irregular, owing to the peculiarity of the mode in which they were produced, or to subsequent abrasion by water.

In those portions of the State that are composed of gneiss, particularly in Worcester county, we frequently meet with bowlders of a rock that appears when broken, exceedingly like the unstratified greenstone that has been described. It is, however, more decidedly crystalline in its structure ; yet I am inclined to believe that it ought to be regarded as unstratified greenstone: certainly near the west line of Pelham, where is a bed of considerable extent. The erratic blocks are often two or even three feet in diameter; and in the bed is no appearance of stratification. In two instances, (in Rutland and near the mouth of Miller's river, in Montague,) I have met with genuine veins of greenstone in gneiss; in neither case, however, of much width; in the latter about two feet.

Under talcose slate I have mentioned, on the authority of Mr. A. B. Chapin, a ledge of greenstone connected with that rock in Somers, Ct. That gentleman informs me, also, that trap (greenstone) occurs in several places in Connecticut on the east side of Connecticut river; as in the southeast part of Manchester, and the eastern part of Glastenbury; where it contains copper ore: also near the church in Vernon, in Bolton, and in Somers. Mr. Chapin rather inclines to the opinion that these are points of a continuous range, extending northerly from Wethersfield, and connected with the new red sandstone. But since that at Somers is associated with talcose slate, I am suspicious that at all these places it may be connected with primary rocks; and in fact belong to a hornblende slate formation; though I doubt not but it is genuine greenstone. Whether it be connected with primary or secondary rocks, is of little consequence, except so far as relates to the epoch of its production. At present I am disposed to believe that beds or irregular masses of greenstone are much more common than I had formerly supposed, along the western margins of that *talus* of primary rocks, which forms the eastern margin of the valley of the Connecticut. Sometimes these beds are in talcose slate, as in Somers; sometimes in gneiss, as in Pelham; and doubtless sometimes in other rocks. But they are always quite distinct from the trap ranges of that valley described above.

Situation of our Greenstone in relation to other Rocks.

This subject has been necessarily somewhat anticipated. But a more particular statement of facts concerning it seems desirable.

It has already been stated that our unstratified rocks occur in three modes: first, as protruding irregular masses: secondly, as overlying masses; and thirdly, as veins. The first and last modes are most common.

Since most of the greenstone in the eastern part of the State is not connected with stratified rocks, it must be referred to the first of these modes; except in those comparatively few instances, where it forms veins in the other unstratified rocks. I have never been able to find a satisfactory example, in which the greenstone distinctly overlies either porphyry, sienite, or granite;* although in numerous instances I have found a gradual passage from this rock into the two latter. But this is as likely to take place laterally as in a vertical direction. Examples of this gradual transition between these rocks are common south of the Blue Hills, as in Randolph, Stoughton, &c.

Wherever I have seen this rock associated with the graywacke and argillaceous slate in the eastern part of the State, it either occupies veins, or protrudes itself in some other form, among, or between the strata. Professor Webster, however, says, that it is sometimes superincumbent upon the clay slate in Charlestown.† It has there also the appearance of being regularly interstratified with the slate. But I am satisfied that this is a deception; that is to say, these supposed beds are connected with some unstratified masses. Yet I think it extremely probable that some of the greenstone in the vicinity of Boston has resulted from the fusion of clay slate; and perhaps it is possible that a particular portion of the slate might be converted into greenstone, while that around it might remain but little changed; and in such a case, the rock might at the surface appear interstratified with the other. In such a case, however, we should rather expect that the slate would be converted into hornblende slate: and Professor Webster says that some of the clay slate in Charlestown does pass into hornblende slate: and I would remark that much of the greenstone in the vicinity of Boston resembles exceedingly that variety which is associated with hornblende slate: indeed, as already stated, some of it is associated with hornblende slate. But for the most part it appears to have been subject to so entire a fusion that the schistose and stratified structure is lost; and hence it seems most proper to describe it as unstratified greenstone: although if it be true that all greenstone results from the same source as hornblende slate, it may be difficult in some cases to distinguish between them.

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*Professor Webster says that it overlies compact feldspar in Charlestown; Boston Journal of Philosophy, vol. 1. p. 282.

†Bost. Journal Philosophy, vol. 1. p. 285.

Prosessor Webster, in his excellent account of the geology of the region around Boston, states that the veins of greenstone in the graywacke conglomerate of that vicinity, run about 10° W. of South, and 10° E. of North. All such veins are probably of nearly cotemporary origin: their parallelism being explicable only on the supposition of their having been produced by the same cause.

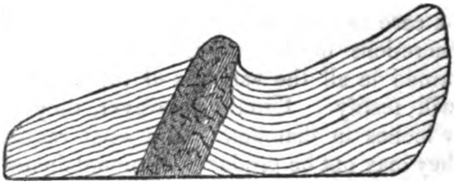
The promontory of Nahant presents an interesting exhibition of greenstone veins, both in the argillaceous slate and the sienite. I have, however, described these veins so fully under graywacke, that a few more facts only need be added. Only a small remnant of the slate remains upon this promontory: and this is intersected by so many and so large veins, that nearly one half of the surface is greenstone. And yet the layers of the slate appear to have been but little thrown out of their original position: for their dip and direction correspond essentially with those of the same rock in other places. In such cases it seems to me impossible that the slate should have been solid at the time the greenstone was intruded among it, unless we suppose it to have been cut through with numerous fissures: and occurrence which in the present case is hardly probable; since some of the veins are ten feet thick, and quite numerous: and I cannot conceive how mere desication should have produced such fissures. But I can conceive how melted matter may have been forced through unconsolidated clay, without disturbing it latterly but a short distance: and perhaps this was the mode in which the veins at Nahant were introduced. If so, it is probable that the consolidation of the slate, and even its conversion into flinty slate, might have resulted from this intrusion.

There is one fact, however, that rather militates against such a supposition. We find there two sets of veins; one of which intersects the other; and penetrates the adjoining slate. We here trace distinctly three epochs of formation of the slate and greenstone. First the slate, secondly the veins that intersect it, and are themselves intersected by other veins: thirdly, those veins that cross both the first named veins and the slate. As to the intervals between the production of these three varieties of rock, we can scarcely form a conjecture. The slate having been deposited originally from water, must have required a period of considerable length, previous to its consolidation: But the two sets of veins might have been introduced almost simultaneously; since this might have resulted from two paroxysmal efforts of the same eruptive force.

The greenstone occupying these veins at Nahant, varies in texture from the finest siliceous slate, to coarse sienite. The veins sometimes run parallel to the strata, and would be regarded by some geologists as regularly interstratified with the slate. And they would be confirmed in this opinion by the apparently distinct stratification of one of the varieties of the greenstone on this promontory, particularly at a place about fifty rods northwest of the large hotel. The rock here is coarse and appears to be passing into sienite: It is divided into parallel portions by seams a few inches apart; and looking only to this spot, I do not see why the evidence of stratification is not almost complete. But if, as an almost universal fact, greenstone, sienite, and granite, are certainly not stratified, it is a presumptive evidence that they never are so: Apparent exceptions it is reasonable to explain on other principles. And in the present case,there is a principle that may afford a solution of such a case as that mentioned above. I refer to the formation of concretions in the unstratified rocks. That they are frequently formed in all the varieties of these rocks, the records of geology will testify. Usually, however, they are only a few feet, or a few inches in diameter. But what reason can be adduced why they may not be produced of mountainous bulk? Their origin is, indeed, obscure: but probably their formation depends upon some modification of the laws of crystallization. And if so, who can tell through how large a mass of matter these laws may operate. In an example of apparent stratification in our granite, which I shall shortly describe, we have an opportunity of ascertaining that the layers are of a spheroidal form, although they cover a mountain of no inconsiderable size. And in all cases which I have met with, it is only a part of the rock that is apparently stratified. This is the case at Nahant. There must then have been a peculiarity in the cause that could thus have affected one portion of the formation and not another. In some instances I have explained a partial and non-continuous stratification in rocks, (ex. gr. limestone and hornblende slate,) by supposing one part entirely, and the other only partially melted. But in the rocks under consideration, the division of the pseudo-strata is too distinct to admit of such an explanation: while the schistose structure is always wanting. Upon the whole, it seems to me that in the present state of our knowledge, sound philosophy requires that apparent stratification in rocks usually unstratified, should be regarded only as examples of a concretionary structure.

The geologist who may have occasion to spend several days at Nahant, will do well to give the spot a very thorough examination. I do not flatter myself that I have brought to light all the interesting facts which may be there developed; although I have exhibited enough to show it to be an interesting field for research.

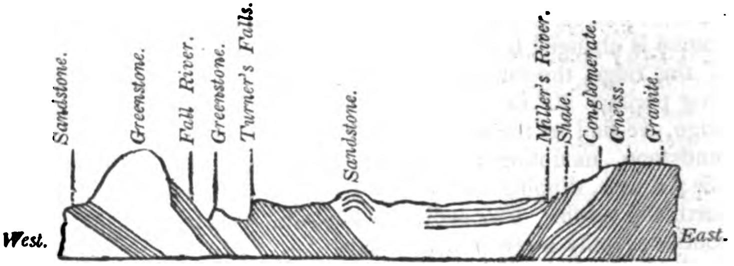
The protrusion of the unstratified rocks through the stratified ones by internal igneous agency, now admitted by most geologists, has led observers to examine carefully for evidences of mechanical disturbance near the line of contact. They have, I believe, found less proof of such disturbance by the intrusion of greenstone, than in the case of the older rocks, as sienite and granite. Every such case, therefore, deserves to be noticed. If I mistake not, the following sketch of a vein of greenstone in argillaceous, slate is an example of this sort. The dike is about 10 feet thick, and the general dip of the layers of slate in the quarry, is about 30° southeast. But as shown in the figure, near the greenstone it is considerably curved upwards in the contrary direction. The quarry, where this example occurs, is about half a mile north of the Powder House in Charlestown.



Greenstone Dyke in Clay Slate: Charlestown.

For the most part, the greenstone in the valley of the Connecticut, is interposed in thick masses or beds, between the strata of sandstone. In Massachusetts I have never met with a mass of this rock which I have regarded, strictly speaking, as superincumbent: though in Connecticut, such examples are said frequently to occur. And I am apprehensive that not a few geologists would describe Holyoke and Tom as instances of overlying rocks. For on examining their western precipitous faces, we frequently find the sandstone cropping out beneath the greenstone: and if we go to the other side of these ridges, it is rare that we find the sandstone lying upon the greenstone. Yet this is sometimes the case; and the sandstone always appears at no great distance in the valley, having such a dip as would cause it to rise above the greenstone. I hence infer, that originally, nearly all the greenstone was interposed between the strata of sandstone; and that subsequent abrasion has removed the latter rock. Even in those cases where we find insulated masses of the trap lying upon the sandstone, there is reason for supposing that it is the wreck of one of these interposed masses: disintegration and abrasion having effected the destruction of the other portions of both the rocks.

At Turner's Falls, Connecticut river has disclosed, between Montague and Gill, an interesting section across the sandstone and greenstone, not less than three miles long. In the 6th Vol. of the Am. Journal of Science, I inserted a very detailed view of this section; but having examined it recently with more care, I shall give a corrected sketch; which, though less particular, will I trust be found more accurate and instructive. It commences on the western side of the greenstone ridge against which Connecticut river impinges, a little below Turner's Falls, and by which its course is changed from northwest to south. At the western base of this ridge, the sandstone crops out beneath the greenstone, dipping perhaps 20° or 25° east. After passing easterly over this ridge, we find at the mouth of Fall River, another variety of the sandstone, mounting upon the greenstone at an angle of about 45°; that is, dipping easterly by that quantity, and running nearly north and south. Proceeding in the same direction, the sandstone continues only a few rods, perhaps 15, when we find it on the north shore of the Connecticut river passing under another ridge of greenstone, 15 or 20 rods thick. On the east side of this second ridge, we find a similar variety of slaty sandstone dipping about 50° east. Several varieties of sandstone, some red, some gray, some fine grained, and some coarse grained, appear, as we pass along the same shore, with a dip between 40° and 50° east, for more than a mile. There we strike a somewhat more elevated ridge, which appears on both banks of the river, consisting of a brecciated indurated sandstone, described among the varieties of new red sandstone, whose strata are somewhat saddle shaped on the north shore, though quite indistinct. Beyond this point the shores for some distance are less bold, and no rock is visible for half a mile. When it again appears, the direction of the strata becomes east and west, and the dip from 30° to 40° south. Hence only the horizontal edges of the strata can be shown on the section. But when we come within 100 rods of the mouth of Miller's river, the sandstone slate or shale is suddenly bent upwards several degrees on its eastern edge, so as to dip westerly. On the southern bank the very spot where the flexure takes place is visible. Advancing towards the mouth of Miller's river, the westerly dip rapidly increases, and within a few rods it approaches 90°. Then for a considerable distance succeeds a coarse conglomerate, in which I could perceive no marks of stratification. For a few rods beyond this rock, diluvium hides the rock in place, and then, before reaching Miller's river, we strike a formation of gneiss, hornblende slate, and mica slate, with granitic gneiss and granite, which constitute the western margin of the gneiss range of Worcester county. The strata of these rocks, at the mouth of Miller's river, and on the east bank of the Connecticut, (for we have now reached the spot where this river runs southerly,) run a little west of south and east of north, and dip to the west between 30° and 40°.



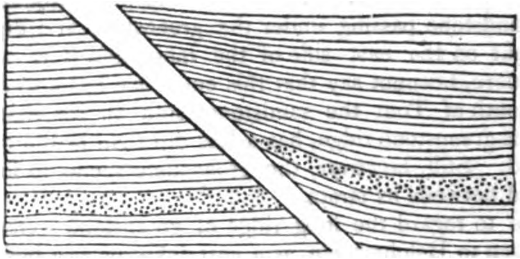
Section between Montague and Gill.

It will be perceived that the above section is intended to embrace every thing important on both banks of Connecticut river, and is not meant to be geometrically accurate. Those parts which are the most interesting occupy more than their proper proportion of the distance; but this produces no geological error. The part of the section most likely to produce an erroneous impression, is where the sandstone strata are represented by horizontal lines: for these strata, as already stated, do in fact dip 30° to 40° south. This change in the direction of the strata appears to result from the fact that the greenstone ridges, towards the western extremity of the section, with the accompanying sandstone, take a northeasterly direction for two or three miles, rising into considerable hills, and forming an axis of elevation, to which the strata just referred to are in a measure conformable. Not improbably also, the elevating force, which has acted on the side of the gneiss and granite, may have operated in wheeling these central strata still farther, so as to bring their direction nearly east and west.

In another place I shall refer to the important bearing which this section has upon the theory of the origin of our greenstone: but in this place I wish to show more particularly the relative situation of the greenstone and sandstone. It will be seen that the former occurs in somewhat wedge-shaped masses, between the strata of the latter, and I believe that the above section represents the mode in which nearly all the greenstone in the Connecticut valley occurs. On the western slope of Mount Toby, in Sunderland, we find a narrow strip of the greenstone interposed between the sandstone strata; although I cannot say that it is wedge-shaped; the opportunities for ascertaining, the dip being very poor. Along the western and northwestern face of Mount Holyoke, however, we meet with the sandstone in several places, (although not very easy to find,) passing under the greenstone with a dip of 15° or 20°. On the opposite side of the mountain the strata are sometimes found elevated 50° and even 60°; as may be seen where the stage road from Northampton to Belchertown crosses the greenstone ridge; and as we recede from this ridge, towards the east, or south-east, the dip diminishes. In the west face of Mount Tom, we find the sandstone passing under the greenstone at a dip from 15° to 20°: but on the east side of the mountain, it is no greater; and, therefore, I cannot say that this eminence has a wedge-shaped form. South of Tom the sandstone both on the east and west sides of the greenstone ridge, has a less dip than in the cases above mentioned. Still, however, the greenstone seems to form a mass interposed between its strata.

Are we to regard the long ridge of greenstone extending from New Haven to Belchertown, as a vast dyke, or as a bed, or simply as a protruding irregular mass? Its great length, (though not greater than the celebrated Cleaveland dyke in England,) and especially its great width in some places, will hardly permit us to call it a dyke, as geologists usually employ that term. A still stronger objection in the minds of many, would be its general conformity in direction to the strata of sandstone. But near its northern extremity, it is obvious that this conformity is in a good measure lost. For Holyoke, running nearly east and west, evidently crosses the strata in some degree: or rather, these same strata which farther south have their western edges elevated by the greenstone, on the southern side of Holyoke, have their northwestern edges raised: although, as the mountain makes a gradual curve to the right, the strata appear to be conformed to its sides. Upon the whole, however, while we must admit, it seems to me, that this extensive range was originally protruded through the strata of sandstone in the same manner as dykes are, yet it may be better to regard it as a protruding ridge, rather than apply a term to it which has not usually been so extended in its meaning.

Genuine and distinct veins of greenstone in the new red sandstone of the Connecticut valley, are not common. In Massachusetts I have not met with one; but in Connecticut they are more common. The following is a sketch of a case of this kind, which I took several years ago, in a ledge a little east of East Rock, near New Haven, on the turnpike road from thence to Middletown. Most of the ledge is a red rather coarse sandstone, from 20 to 30 feet high. The lowest stratum is a fine grained red sandstone; the next above it, a coarse gray sandstone, about six inches thick. The rock dips from the observer about 25°; so that it must be represented as horizontal on the section. The vein of greenstone is about a foot wide at the bottom, and something more as it ascends. It appears to consist of indurated clay, or wacke. It ascends through the sandstone at an angle of about 45° with the horizon, and on the upper side of it the different layers of sandstone are elevated, so as not to correspond with the same layers on the opposite side of the vein. The coarse gray stratum above mentioned, exhibits this effect most obviously.



Greenstone Dyke in New Red Sandstone; East Haven, Ct.

The inferences of a theoretical nature from such a case as the above, if there is no mistake in my representation of it, are too obvious to escape the notice of any one. If we have not proof here of an internal force erupting the matter of the vein, I know not how such proof could be given. But more of this in another place. I thought the case too interesting not to be noticed, although out of Massachusetts; and I shall take the liberty in several other instances, as I have already done in some cases, to introduce examples from other parts of New England, illustrative of important geological principles. In respect to the veins of the unstratified rocks, especially, I shall give the results of my observations for the last twelve or fifteen years in various parts of New England, since the subject is one of special interest.*

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*To show how the examples which I shall adduce are regarded by a distinguished geologist in Europe, I take the liberty to subjoin a translation of a letter which I received two or three years ago, from Counsellor Von Leonhard, Professor of Mineralogy in the university of Heidelberg, Germany, in answer to a communication which I had previously made to him at his request, detailing several of the most striking cases of veins and protruding masses, which are embodied in this Report. I give the letter entire, since several of the examples given by this veteran *savant* although to be met with in a few works, are yet not commonly to be found.

"Heidelberg, December 14, 1829.

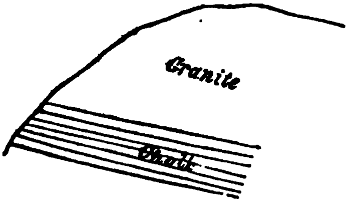
"Sir, Your letter of the 20th October, with which you have favored me, I have duly received. A thousand thanks for the trouble you have taken to enlighten me with so many interesting facts concerning the granite eruptions of your country. Your observations are of the highest importance, and it is very much to be desired that you should publish them forthwith.* You have requested that I should give some account of the elevation of granite in this country as well as in England and France.

"One of the most interesting observations that have been made on this subject,

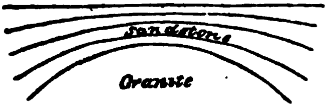
*In a subsequent letter I requested Prof. Leonhard to make such a use of these facts as he thought proper; and not unlikely some of the cases which I shall produce, have ere this been published in Germany.

On the south side of mount Tom, on the bank of a small steam, and close by a saw mill, which is only a few rods from the stage

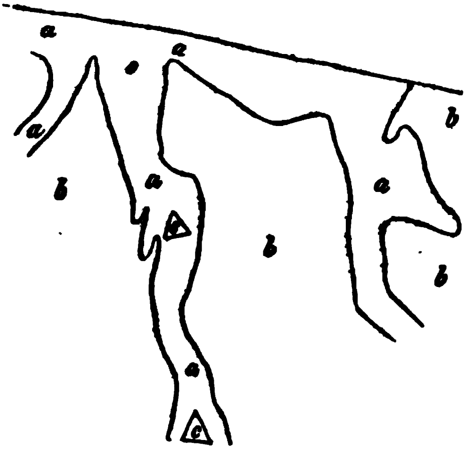
is that of Weiss, near Meissen in Saxony. Granite, or rather sienite, there appears superimposed upon the *planerkalk* which belongs to the chalk formation.



A hundred paces from my house is a protrusion of granite. The predominant rock in the vicinity is the variegated sandstone. In one place we see the strata of sandstone bent upwards and the granite beneath.



" You are doubtless acquainted with the important observations of J. Hall, in Galloway in Scotland. Veins of granite, *a a*, &c. have penetrated the transition argillaceous schist, *b b*, &c. enveloping also the fragments, *c c c*, of the same, and overspreading the schist in part. The schist has suffered numerous disturbances from the influence of the granite and is changed at the place of contact by the volcanic heat.



"You speak of your greenstone. Is it *diorite* or *dolerite?* From your description I suspect it to be dolerite,* that is, a greenstone into whose composition amphibole enters, and not pyroxene.

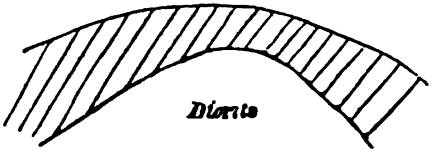
In the Hartz facts occur similar to those which you have observed. I shall be much obliged to you when you send another box of minerals for exchange to the

*After what I have written on this rock, it is hardly necessary to say that this conclusion is correct.

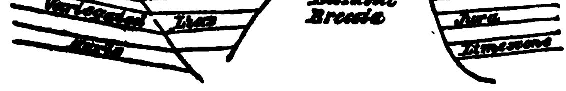
road from Northampton to Hartford, the following case occurs in the new red sandstone. A deposite of greenstone, the remains of a large vein or protruding mass, is here seen to lie in an oblique direction upon the elevated edges of the sandstone. Towards the upper part of the section, the layers of sandstone are curved considerably upwards, so as to increase the dip of their upper extremity, raising it, indeed, almost to 90°. Must we not impute this

Comptoir, to put in some specimens of greenstone, that I may institute a comparison. In the Hartz we see that the *diorite* assumes an amygdaloidal texture, becoming cellular near its point of contact with the schist. Does any such phenomenon occur with you ?[*]

Transition Schist.



"Since I had the honor of writing to you, I have continued without intermission to collect facts for my work on the Basalts. But it will be a long time before I can bring it to a conclusion. In 1828 I visited Auvergne. This without contradiction is classic ground as to this matter. You are doubtless acquainted with the work of Srope, (*Central France.*) But I have ascertained some new and quite interesting facts. Among others the projecting mass of basaltic conglomerate which rises through the beds of lacustrine limestone, (it bears the name of *Puy de la Piquette*,) embraces fragments of that limestone full of many fine crystals of mesotype and apophyllite. Last summer I visited the Suabian Alps. In these mountains we find a number of important facts. We count there at least thirty eruptions or elevations of basaltic breccias through the beds of Jura limestone; and these conglomerates contain a number of small fragments of limestone, which have been variously modified by the heat of the conglomerates.



"Finally, I pray you to preserve in full, an account of the phenomena of basalt, diorite, and amygdaloid, as well as of the conglomerates which accompany them; and I would request you to send me these details.

* * * * * * *

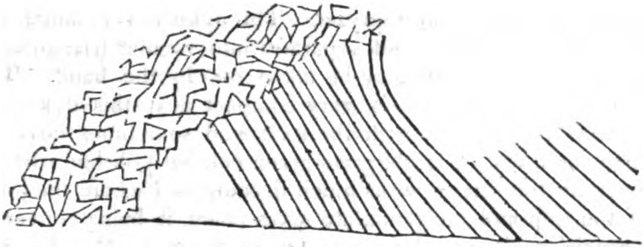
"I have the honor to salute you with the greatest respect:

"Yours with devotion,

LEONHARD."

[*] Precisely the same, as I shall mention more particularly farther on.

flexure to the protrusive force of the greenstone, when first it was elevated to the day light?



Junction of Greenstone and Sandstone: Mount Tom.

Chemical Effects of Greenstone upon other Rocks.

In other parts of the world, it is a common case to find the rocks lying in contact with the greenstone, essentially changed in their characters, for a greater or less distance from the place of junction. This is most striking where the limestone is the rock invaded by the trap. Similar effects are not wanting in the rocks of Massachusetts, that are traversed by greenstone. Yet it appears to me that they are hardly as common or striking as in some countries; judging from the descriptions of geologists. One reason may be that greenstone here rarely comes in contact with limestone. The following are the principal examples of this phenomenon which I have met with.

The influence of greenstone veins at Nahant, in converting argillaceous slate into flinty slate, and where carbonate of lime was present, into chert, has been fully described under gray wacke.

Professor Webster describes a mass of trap, in Charlestown, as superincumbent upon a rock which he calls compact feldspar, 'which has many of the characters of clay slate, and in the immediate vicinity of the trap rock has a degree of hardness, a compact structure, and fracture almost like that of hornstone,—the slate seems to have undergone a great and remarkable change.'*

In season for the present edition of my Report, I have received from Dr. C. T. Jackson, an interesting account of a dyke of '*Greenstone Trap,*' traversing the gray wacke conglomerate in Roxbury. It is on Mr. Dudley's farm nearly opposite the seat of Gen. H. A. S. Dearborn, Esq. The strata of the conglomerate there run N. W. and S. E. and dip N. E. 30°: the dyke runs north and south and dips 80° W. At the top of the ledge it is ten feet wide and nine feet at the bottom: the ledge being 31 feet in perpendicular height. The conglomerate near the dyke contains an abundance of serpentine.

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* Boston Journal of Philosophy, Vol. I. p. 282.

'This dyke,' says Dr. Jackson, 'consists of a mass of greenstone trap, black on the surface, but when broken exhibits a greenish color having crystals of feldspar scattered through the mass sometimes rendering it porphyrytic. The dyke is very much decomposed on the surface and separates into regular triangular or four sided prisms, which may be taken out by the hand. The paste of the conglomerate is very compact near this dyke, and serpentine is found mixed with the rock, and sometimes covering the whole rock with a bright grass green colored polished surface, but generally the serpentine is much decomposed where the junction of the trap and conglomerate takes place, it being converted into a greyish white powder. Sp. Gr. of the trap—2.304. Before the blowpipe it melts into an opaque black enamel. With carbonate of soda melts and is decomposed with difficulty. effervescing considerably. The glass being placed in dilute muriatic acid leaves a deposit of silica. The powder of the mineral is greyish or bluish gray. It attracts the magnetic needle, but the mass does not possess polarity. From the above examination it will appear that the paste of this trap consists of feldspar and hornblende intermixed, and that it contains prot-oxide of iron, as a component. The hornblende and feldspar are often distinctly observable by the eye. The feldspar appears to yield to the action of the air and water, so that the decomposed pieces consist mostly of hornblende and are easily crushed. The decomposed surface is of a deep brownish black color, the color being produced by peroxidation of iron. I shall soon make a chemical analysis of this trap. I suppose this dyke to have been protruded through the superincumbent conglomerate by expansion of subterranean origin, and that this power raised up and indurated the conglomerate, which is considered of transition formation. I have observed in many places the passage of our greenstone into sienite, and think we shall be obliged hereafter either to make sienite more recent, or to place our greenstone at a remoter origin than is generally believed to belong to that rock.'

In the Connecticut valley the most striking chemical effects produced upon the sandstone by the greenstone, are induration, a vesicular structure, and change of color. In the 17th vol. of the Am. Journal of Science, Professor Silliman has described a most interesting example of all these effects, as they appear in a quarry, nearly a mile long, at Rocky Hill, about three miles southwest of Hartford. 'The trap is here superincumbent upon the sandstone, and this latter rock is changed to the depth of about four feet below the junction. Ascending from that depth, it begins to grow firmer; the color grows lighter, the red vanishes and it becomes

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[*] Boston Journal of Philosophy, Vol. I. p. 282.

dark gray—light gray—ash gray, and in some places almost white; while at the same time the firmness is much increased, so that from being a very soft and tender argillaceous sandstone, easily splitting into laminae, it has become hard, and difficult to break, striking fire with steel like an overburnt brick, and its fissile character is almost or quite destroyed.'

'But this is not all. At the depth of about two feet, rather less than more, the altered sandstone begins to grow vesicular. Fine pin-hole cavities make their appearance; they are very numerous, and the solid substance which surrounds them becomes semi-vitreous and loses the appearance of sedimentary or fragmentary matter; as we ascend towards the trap the vesicles increase rapidly in size, and at and near the junction they are both numerous and large.'

This vesicular structure is still more remarkable in the trap, extending several feet upwards; and near their junction, the two rocks can hardly be distinguished, and appear as if melted together.

Similar phenomena, more or less strongly marked, present themselves both in Connecticut and Massachusetts, where the contact of the two rocks is visible. On the east side of Mount Tom in Northampton, and on the south side of Holyoke, the vesicular character of the sandstone is most obvious: as is that also of the greenstone. (No. 286.) From the description that has been given of the relative position of these rocks in those places it will be recollected that the sandstone is uppermost. The cavities are sometimes filled with some mineral, as carbonate of lime, subsequently introduced; but the red color of the rock is generally retained: sometimes, however, it is not easy to distinguish this amygdaloidal sandstone from trap, without close inspection. Yet in most cases the line of junction is distinct, and the schistose structure of the sandstone is not lost. The greenstone, as already mentioned, is in these instances much more vesicular than the sandstone, and to an unknown depth. The cavernous base, the cavities not being usually filled, differs but little from indurated clay; and some circumstances have led me to suspect that the rock in fact consists of argillaceous sandstone or shale, which has been fused.

A little below Turner's Falls on the Greenfield shore, the junction of these rocks may be advantageously examined, where they occupy the same relative position as above mentioned; that is, the sandstone is the superior rock. There it dips from 40° to 50°: but I did not perceive in it any cavities; nor is the red color or the fissile character destroyed. Connecticut river here has worn away nearly all the sandstone, except an occasional patch, for one or two miles: but where these patches remain, a fine opportunity is afforded for observing the junction. And in some places I noticed that small rounded masses of the amygdaloid were partially entangled in the sandstone: as if, when the melted mass of greenstone was forcing its way upward, and pressing hard against the incumbent sandstone, portions of the former rock, while yet partially solidified, were worn off and rounded by the latter. More frequently we see fragments of the sandstone insulated in the greenstone; being perhaps unmelted portions of the former rock.

For several feet below the surface of the amygdaloid at this locality, it is not uncommon to see that rock divided into parallel portions, whose surfaces correspond in dip and direction with the strata of sandstone. The thickness of these layers is from one to four feet. But they do not extend through the whole mass of rock, and can, therefore, hardly be considered as genuine strata.

The existence of so much amygdaloidal greenstone on the eastern or upper side of the ridge, (for it must be recollected that such is the dip of the sandstone embracing the trap as to render the eastern the upper side,) while it is comparatively rare and far less porous and irregularly situated in the lower parts of the range, leads naturally to an inquiry as to the cause. It may be sufficient to say, that the gaseous matter extricated by the intense heat of a large mass of rock in a state of fusion, would naturally be forced to its upper part by the greater pressure below: although in the example described by Prof. Silliman, such does not appear to have been the case. Since, however, the base of the rock on the east side of the ranges above named, is more argillaceous and less crystalline than that of the rock on the western or lower side, I am disposed to believe the former more favorable for retaining the gas or vapor than the latter.

When the water is low we have an instructive exhibition of the junction of greenstone with the subjacent sandstone at Titan's Pier in South Hadley. A considerable part of the trap near the sandstone is a breccia; and one of the ingredients is clay, indurated almost to the hardness, and exhibiting the light gray color of hornstone, although not exactly that substance; especially if a mixture of limestone in the original rock be essential to its production. This seems rather to have formed the paste in which are cemented dark pieces of trap. This rock extends but a short distance upwards from the line of junction.

The most interesting effects at this spot are exhibited, however, in the sandstone beneath the trap. Like that near Hartford, for two or three feet its schistose structure is in a great measure obliterated, although its stratification remains. It is also of a light gray color. On breaking it, it exhibits a semi-crystalline structure, bearing considerable resemblance to some varieties of fine grained granite. (No. 170.) But the most curious fact of all is, that this rock exhibits in some places a decided tendency to a columnar form. I cannot say, indeed, that any perfectly formed prism can be found. Still the sandstone exhibits several unequal sides of a prism, perpendicular to the planes of stratification, thus coinciding with the less perfect columnar structure of the greenstone immediately above : so that at a little distance one does not perceive the line of junction between the two rocks.

I have met with no geological writer but Dr. Macculloch, who has described examples of columnar sandstone; and he mentions but two cases in nature, both in Scotland. Another case, however, is noticed by him in the hearth stone of a blast furnace.* This last example is very instructive, as showing that heat, if long continued, may produce the columnar structure in sandstone even though not intense enough to melt it. The application of this case in explanation of the columnar structure of the sandstone at Titan's Pier, is too obvious to render its formal statement necessary.

Some of the sandstone of the new red sandstone is highly micaceous: this variety, where it occurs near the greenstone, can hardly be distinguished from mica slate. (Nos. 177 to 179.) I will refer only to two localities of this rock, viz. at Turner's Falls and at the north end of Mount Tom, at the spot where the sketch on page 421 exhibiting the junction of the two rocks, was taken. Can there be any doubt that these examples are in fact a partial conversion of the sandstone into mica slate by the heat of the greenstone?

I know of but one place in the valley of the Connecticut where greenstone comes in contact with limestone; and that is in West Springfield. Perhaps even there an actual contact does not exist, yet the greenstone is separated from the limestone in some places only by a narrow strip of sandstone. And a part of the limestone is more or less frequently converted into tripoli: that is to say, the carbonic acid is expelled, leaving the argillaceous and silicious matter by itself. Probably this was the effect of heat: though I am not very confident that the tripoli was produced in this manner. A part of the limestone at that place is very much indurated, so as to possess almost the brittleness of glass when broken.

Mineral Contents.

It is not unexpected, though gratifying, to find in our greenstone the same materials as occur in the trap rocks of Europe.

In describing the new red sandstone I have given an account of several veins in that rock, of sulphate of baryta and native copper, green carbonate of copper, with pyritous copper and the red oxide of that metal. These veins often extend into the greenstone a considerable distance. But for the particular localities I would refer to the description already mentioned.

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*System of Geology, vol. 1. p. 172.

According to the Messrs. Danas,* a vein of magnetic oxide of iron occurs in the greenstone at Woburn; though not extensive enough to render it an object for the miner. Intimately mixed with this ore is pyritous copper; and this last is invested sometimes with the muriate of copper. Quartz and amygdaloid at Brighton, and rolled pieces of granite at Medford, contain the same mineral. They state also that micaceous oxide of iron exists in the greenstone at Charlestown.

According to the same gentlemen, asbestus is found in fragments of greenstone in Brighton and Dedham; and I have found it in one of the anomalous varieties of this rock at Nahant. Probably, however, it is comparatively rare.

Epidote, as already mentioned, exists abundantly in the greenstone around Boston; but never to my knowledge in that in the Connecticut valley. Generally it is disseminated through the greenstone; but sometimes it occurs in veins, and is then usually compact, though often crystalized. At Breed's Hill is a locality; and a much better one at Nahant.

The cavities of the amygdaloid are sometimes occupied by a dull green foliated mineral which appears to be chlorite. The folia have in general a radiated structure, and sometimes invest calcareous spar. (No. 1173.) A little below Turner's Falls in Gill, just at the mouth of Fall River, on the east bank, is the best locality of this mineral with which I am acquainted. More frequently the cavities are occupied with earthy chlorite, and the specimens of this kind are very common along the eastern side of the ranges of greenstone in the Connecticut valley; as in Greenfield, Deerfield, South Hadley, Northampton, and West Springfield.

At the locality just referred to at the mouth of Fall River, occurs the rare mineral chlorophoeite: which has not to my knowledge been found in any other place on this side of the Atlantic. It is abundant in the projecting mass of greenstone that appears at the junction of the Connecticut aud the small river just mentioned; on the east bank of the latter; and the spot can hardly be mistaken by any one desirous of finding it. This mineral, when the rock is first broken, is of a dull green color: but after a few hours exposure becomes nearly black. After long exposure, however, some specimens assume a dark brown color. For the most part the nodules,—often half an inch and sometimes more than an inch in diameter,—exhibit a fibrous structure, the fibres radiating from one or more centers in the same nodule. The mineral is easily scratched with a knife and the powder is of a dull green color. When fractured, however, it appears brittle. Sometimes calcareous spar is enclosed within the chlorophoeite; but very rarely are the nodules hollow. If I mistake not, in one or two instances I have observed a foliated structure in specimens. There seems little danger of exhausting this locality. The same rock contains disseminated prehnite, chlorite, and pyritous copper. It is however, but slightly amygdaloidal. Mr. Shepard has recently announced the existence of datholite in Middletown, Ct. in a rock exactly resembling that containing the chlorophoeite; nor can I doubt but this mineral will be found in Massachusetts.

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*Mineralogy and Geology of Boston, &c. p. 66.

Prehnite has been found in the greenstone in the vicinity of Boston, particularly in Charlestown. But it is more common in the valley of the Connecticut. Near the chlorophoeite locality just described, on the Greenfield shore of the Connecticut, it is not uncommon in amygdaloid. There its color is nearly white. In general it is more common on the eastern side of the greenstone ridges, than on the western; for example, where Deerfield river cuts through a ridge of this kind in Deerfield, and on the east side of the same ridge four or five miles farther south, in a part of the town called Pine Nook: also in West Springfield. But it is found likewise on the west side of these ridges; as at a spot one mile east of the village of Deerfield, and at another about the same distance nearly east of the village of Greenfield. No very rich specimens of this mineral, however, are met with in our greenstone.

Augite of an iron black color and in imperfect crystals or in veins, is sometimes met with in the tufaceous greenstone of the Connecticut valley: as at a spot one mile east of the village of Deerfield.

Several varieties of the quartz family are found in the greenstone of Massachusetts, principally in that of the Connecticut valley. Limpid crystalized quartz is found frequently in the form of geodes, and sometimes these crystals are amethystine, of a delicate though not very deep color. This amethyst has been observed one mile east of the village in Deerfield: on the same range three miles south of this spot and east of the village of Bloody Brook; on Mount Holyoke: and in West Springfield. At the latter place the crystals are sometimes smoky. (No. 1117.)

The quartz that occupies the cavities of greenstone, as at a spot a mile east of the village in Deerfield, is sometimes tabular; and the folia are quite thin and delicate. Sometimes it is radiated, and not unfrequently it contains tabular or prismatic and radiating cavities, once occupied by a mineral. The radiating cavities were perhaps once filled with Thomsonite; at least they resemble that mineral in form. I have seen them three or four inches in length, and crossing one another from different centers.

Chalcedony is not an uncommon mineral in the greenstone of the Connecticut valley. So far as I know it is wanting in the greenstone around Boston: and this fact, with the almost entire absence of an amygdaloidal structure, are marks of peculiarity well worthy of notice. In the Connecticut valley the chalcedony is usually in small nodules, rarely more than one or two inches across. Most frequently its color is milky or smoky gray, and sometimes it appears to be real cacholong. At other times it is of a flesh color, from the lightest to the deepest shade, forming cornelian. Rarely have I seen it yellowish, and closely allied to sardonyx. These varieties are most common in the greenstone range passing east of the villages of Greenfield and Deerfield, and on its western face; but rare on its eastern side.

All the above varieties of the quartz family are sometimes arranged concentrically, so as to form agates. Generally they are small: but some specimens found by Dr. Cooley in the south part of Deerfield, two miles northeasterly from Bloody Brook meeting house, were quite large. The largest of these specimens, nine by six inches in diameter and weighing 23 pounds, was composed of an outer zone of greenish chalcedony half an inch thick; then a zone of flesh colored chalcedony: the center consisted of an amethystine geode. The best of these specimens which I have been able to procure for the collection (No. 1191.) is about six inches by four: the outer zone is cornelian; the second bluish chalcedony, and the remainder limpid quartz, almost filling the cavity. When the outer coat is broken off, the specimen shows a strong resemblance to the human skull; exhibiting protuberances and depressions enough to satisfy the most sanguine phrenologist. Another specimen, three inches in diameter, exhibiting no less than 14 concentric bands, consisting of chalcedony and quartz of various colors. This is a genuine *fortification agate.* Sometimes fortification and eyed agates are exhibited in the same specimen. It is to be feared, however, that this locality is nearly exhausted; at least, until a long period of time shall have decomposed the greenstone much deeper.

Calcareous spar is one of the most frequent of the minerals in the greenstone of Massachusetts; both in that in the eastern part of the State and in the Connecticut valley. Generally it is the laminated variety; sometimes flesh colored, but mostly limpid. Often it constitutes the cement of trap tuff. Sometimes it is in distinct crystals.

A few years since, Prof. Silliman detected selenite in amygdaloid from Deerfield. It was white and retained its water of crystalization.

Several species of the zeolitic minerals have been found in this rock in the Connecticut valley. Analcime has been frequently said to be quite common; but I am suspicious that calcareous spar has been confounded with that mineral: and I dare not say that it exists in our greenstone Nor am I sure that laumonite occurs as far north as Massachusetts, although the greenstone in the vicinity of New Haven contains it. As to chabasie there is no doubt but it has been found in Deerfield, one mile east of the village. It is always crystalized, and almost invariably in the primary form, an obtuse rhomboid. The crystals vary from 1-50th to 1-4th of an inch on their sides; and these are grouped on tabular and pseudomorphous quartz, on prehnite, and on the greenstone: either in fissures, or more commonly in the cavities of the amygdaloid. This mineral seems to have entered these cavities for the most part at a later period than many of the others with which it is associated. For often we find it in the upper part of a cavity whose lower part is filled with another mineral; but never in a reverse order. The amygdaloid in which this mineral occurs is extremely hard, and hence the chabasie has been preserved. It is, however, quite difficult to obtain good specimens.

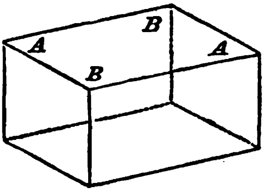
In the amygdaloid on the east side of the greenstone range in Deerfield and Greenfield, I have observed a few rather poorly characterised radiated specimens, exceedingly resembling the Thomsonite of Scotland.

In the greenstone one mile east of the village in Deerfield, a mineral occurs, closely allied in external characters to stilbite and heulandite: and hitherto I have described it as stilbite. But in its crystalline form it differs from both those species, and indeed from any known mineral. I shall, therefore, venture to describe it as new; and I take the liberty to dedicate to your Excellency, as the patron of science, under the name of

LINCOLNITE.

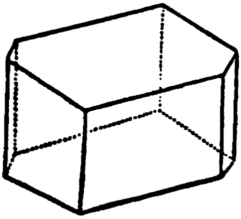
This mineral occurs in minute yet very distinct crystals, which are right oblique angled prisms. Three trials on as many crystals with the common gonometer, gave the following results for the angles of the bases.

First crystal:	Angles *A*, *A*, 61°.
	Angles *B*, *B*, 119°.
Second crystal:	Angles *A*, *A*, 61°.
	Angles *B*, *B*, 120°.
Third crystal:	Angles *A*, *A*, 61°.
	Angles *B*, *B*, 120°.



The mean result of all the trials I have made does not vary much from 60° and 120°. But this may vary from the truth half a degree; I think not more. The bases are commonly bright enough for the application of the reflective goniometer: not so the lateral faces.

I have observed only one modification of this crystal, and that consists of a slight truncation on the acute lateral edges, as represented in this figure. (No. 1202.)



The height of the prism is about equal to the longest edge. It yields to mechanical division only parallel to the bases. It has a lustre somewhat pearly on the cleavage plane, and not unfrequently the folia are slightly curved. It is always white or colorless; sometimes transparent, but generally only translucent. In every other character it corresponds with Heulandite and stilbite. On hot coals it whitens, and before the blowpipe melts into a white spongy enamel.

The crystals of this mineral are mingled, usually in the least proportion, with crystals of chabasie; either in the amygdaloidal cavities of the greenstone, or in its fissures. I have rarely met with a crystal whose longest side exceeded the tenth of an inch: and most of the specimens in the collection will need a microscope for their examination. It is very rare and obtained with difficulty, though small specimens will reward the persevering collector. (Nos. 1200 to 1204.)

At the same spot in Deerfield a radiated mineral occurs, forming sometimes perfect spheres, of the size of an ounce bullet, which may be Lincolnite, though perhaps it is stilbite.

This same radiated mineral is found at Bellow's Falls in Vermont, encrusting gneiss. On examining some specimens which I obtained there a few years ago, I perceive several distinct crystals of Lincolnite, which are quite small. Quite recently I have obtained more specimens; and I am more and more inclined to the opinion that the radiated mineral above spoken of, both at Bellow's Falls and at Deerfield, is Lincolnite.

It is obvious from the preceding description, that this mineral differs from stilbite and Heulandite, only in its crystalographical characters. Stilbite crystalizes in a right square prism. Heulandite comes nearer to Lincolnite; its primary form being a right oblique angled prism. But the angles of its bases are about 50° and 130°; differing 10° from those of Lincolnite. Such a difference cannot be imputed to the imperfection of mensuration; nor can I conceive how it could possibly result from any modification of stilbite or Heulandite. There is, therefore, as much reason for making this mineral a distinct species, as there was for separating Heulandite from stilbite. I am aware that mineralogists have of late exceedingly multiplied species by divisions of the stilbite of Hauy. Beudant, especially, in the last edition of his mineralogy, (1830.) has made no less than five: viz. stilbite, Heulandite, epistilbite, hypostilbite, and spherostilbite; the two last being added by himself. He supposes that when the same elements combine in different and definite proportions and under different forms, they should constitute different species; although in external characters they differ but slightly; and surely no scientific man can object to this principle. But recent discoveries have shown that the same elements, combined in the same proportions, are capable of crystalizing in forms incompatible with each other. This may prove to be the case with some of the new species separated from stilbite, and with Lincolnite among the rest. Yet at present it seems as well entitled to a distinct name as Heulandite, and better than hypostilbite and spherostilbite, whose crystalline form has not been ascertained: much better also than epistilbite, since the controversy concerning it that has been carried on in the European Journals. When this subject shall be better understood than it now is, mineralogists may find it necessary to reform the list of species; nor can we now say which of them must be stricken out.

Theoretical Considerations.

There has been so decided a change within a few years in the opinions of geologists as to the origin of the trap rocks, and there is now so general an agreement in regarding them as igneous products of early times, that a prolonged discussion of the subject in this place will not be necessary. I shall only state the leading arguments in support of this opinion, that will apply to the greenstone of Massachusetts.

1. ***The resemblance in external characters between some varieties of our greenstone and the products of existing volcanoes.*** The amygdaloids are the most striking in their resemblance. In the valley of the Connecticut it is easy to collect a suit of specimens of this description, that could hardly be distinguished from specimens that are frequently brought from the craters of volcanoes, except by the greater freshness of the latter. Let a man pass from Bridgman's tavern in the southeast part of Amherst, to Granby, over the east part of Mount Holyoke, and in the pastures by the road side, he will see hummocks of amygdaloid so much resembling lava, as to remind him of the Phlegrean Fields. And a similar appearance is not uncommon in other spots on the east and southeast sides of Holyoke and Tom.

Some writers regard the minerals peculiar to our greenstone, such as chalcedony, the zeolites, prehnite, augite, &c. as evidence of its igneous origin. But if, as is probable, most of these were infiltrated from solution in water, this proof is not of much weight; especially since they have been found of late in several of the stratified rocks, such as mica slate, gneiss, &c. though I am not aware that they have ever been discovered in rocks of exclusively aqueous origin.

2. *The columnar structure of greenstone.* The same columnar form is assumed by lavas when they are slowly cooled; but in no case by rocks of known aqueous origin. How unphilosophical then, to refer this structure to aqueous agency!

3. *The irregular manner in which greenstone is intruded among stratified rocks.* Water and fire are the only two great agents in nature, as I suppose will by all be admitted, sufficiently energetic to have produced mountain masses of rock: so that we must take our choice between them, unless we can show that both of them were concerned in the work. Now I cannot conceive it possible how any logical mind, that has observed trap rocks in situ, or will attentively consider the manner in which I have shown our greenstone to be intruded in the form of veins and irregular masses among the stratified rocks, can conceive how they could have been deposited in these modes from water. But they are exactly the shapes which melted matter, forced from beneath, through and among consolidated strata, would have assumed. What but a wedded attachment to hypothesis, then, can prevent us from admitting their igneous origin?

4. *The Mechanical effects of greenstone upon the stratified rocks.* I refer here to the evidence that our greenstone has elevated, broken, and dislocated the strata in some instances, through which it has been protruded. The section at Turner's Falls, exhibits a good example of these effects, as well as similar effects of the primary rocks, which last will be noticed farther on. Nearest the greenstone on the upper side, we find the dip to be greatest, gradually diminishing as we recede from the ridge. That this increase of dip resulted from the protrusion of the greenstone, is evident, it seems to me, from the fact that beneath that rock the dip is less, corresponding to that of the formation generally. A similar case I have described on Mount Holyoke in Belchertown. I have also given drawings of less extensive, though not less decided cases of the agency of a mechanical force upon the strata in juxtaposition with the greenstone, whereby a portion of these strata is forced upwards, at Charlestown, Northampton, and New Haven. All these facts, it seems to me, admit but one explanation: and irresistibly lead the mind to the conclusion, that a force must have acted in the interior of the earth, urging the greenstone through the superimposed rocks in a fluid or semi-fluid state.

5. *The chemical effects of greenstone upon the stratified rocks.*

At Nahant we have seen that it has converted clay slate into flinty slate: in Charlestown a similar change has taken place. In the Connecticut valley, much of the sandstone in contact with the greenstone has become vesicular and some of it is highly indurated; and in one case at least, somewhat columnar. Its red color too is often destroyed, its texture rendered somewhat crystalline, and the micaceous varieties partially changed to mica slate. In one case, also, limestone is converted into tripoli; that is, its carbonic acid is expelled.

Now it requires no labored argument to show that such effects as these could have resulted only from the intrusion among the strata of rocks in a state of fusion, or intensely heated. It does not require even a practised geologist to draw this conclusion: for the facts, wherever they exist, impress every man who observes them with this belief.

The occurrence of serpentine on the sides of a greenstone dyke in graywacke conglomerate in Roxbury, as described by Dr. Jackson, is another interesting chemical effect of the trap. Indeed, I know of no other possible mode of explaining this case but by igneous agency.

Upon the whole I cannot see that any thing is wanting to prove the igneous origin of our greenstone. It may be asked, indeed, how it happens, that while existing volcanoes throw up their matter in a conical shape, greenstone forms a continuous ridge, 70 or 80 miles long, with no appearance of a crater or craters. There is reason to believe, indeed, that the mode in which greenstone has been erupted, was considerably different from the operation of existing volcanoes; and that probably the protrusion took place under an immense weight of water: nor can it be imagined how a common volcanic force, which acts in the direction of the radii of a circle, should thus operate lineally. But it is easy to conceive, how the shrinking of the interior part of the earth by refrigeration, faster than the exterior, would produce such linear openings, into which the melted matter from beneath would readily force its way. But more of this ingenious hypothesis in the sequel.

The columnar structure of the trap rocks has never yet received a very satisfactory explanation. From the fact that clay when drying divides into columnar masses, it is natural to inquire whether the columns of trap had not a similar origin. There is, however, one insuperable difficulty in such an hypothesis. The desication of the clay always causes it to shrink, so as to leave interstices between the columnar masses. But no such shrinking has taken place among the prisms of trap. There are no spaces between them: their sides actually touch. Perhaps in the present state of our knowledge we cannot come nearer the truth, than to consider this columnar structure as one of the forms of a concretionary structure. Yet this solution affords no great satisfaction to the mind, so long as we are in doubt as to the nature of a concretionary structure.

We have seen that greenstone is sometimes divided by parallel planes into masses exceedingly resembling strata. If they are not genuine strata, what is their origin?

In all the unstratified rocks, small spherical or ovoid concretions occur, composed of concentric layers of greater or less thickness. These concretions vary exceedingly in size, and are sometimes not more than an inch in diameter. Nor do I know of any principles in geology or chemistry that can fix any limits to their size. Suppose now a concretion to have been produced of mountainous bulk. It is obvious that if only a small portion of its surface be laid bare, and only a few of its envelopes penetrated, these layers may have exactly the appearance of strata; because their curvature is so slight, for a small extent, as not to be perceptible. In this way should I account for the laminar disposition of the trap at Nahant; and I shall apply the same explanation to some examples still more striking in the sienite and granite of the State. In one of these cases I have satisfactorily traced out a concretion of mountainous bulk, and thus found a confirmation to the theory I am advocating.

16. PORPHYRY.

Porphyry has been for so many centuries used as an ornamental stone, and the term has been so often employed by lapidaries and authors who were ignorant of geology, that its popular acceptation is quite too loose for scientific description. Nor are geologists exactly agreed as to its meaning. 'The term porphyry,' says Macculloch, 'is applied to a rock in which crystals of common feldspar are imbedded in a simple or compound base.' 'The word porphyry,' says a writer in the Edinburgh Review, 'signifies at present a rock having a compact basis, through which are scattered crystals of some other minerals.' 'Since the time of Werner,' says the Dictionnaire Classique D'Histoire Naturelle, 'most mineralogists confine the name Porphyry to rocks with a porphyroid structure, composed of a paste of compact feldspar more or less mixed, which envelopes crystals of feldspar ordinarily whitish.' Brongniart defines porphyry as having a 'paste of amphibolic petrosilex, red or reddish, enveloping obvious crystals of feldspar.'

Since porphyry passes into other rocks, we ought to recollect a remark of Macculloch, that 'the term porphyry, when used in geological description, must not always be taken too strictly in its mineralogical sense.' With the latitude which this remark gives, the porphyry of Massachusetts conforms to the strictest of the above definitions.

Mineralogical Characters.

1. *Compact Feldspar.* (Nos. 1206 to 1228.) This mineral, more or less changed by other substances chemically mixed with it, forms, I believe, the basis of all the porphyry in Massachusetts. At any rate, I have found none the base of which I was not able to fuse with a common blowpipe: and this fact, in connection with another, that the great mass of our porphyry has a base of well characterised compact feldspar, has satisfied me that this is the predominant ingredient in the whole of it. But this compact feldspar, both that which forms the paste of porphyry, and that which contains few or no feldspar crystals, varies exceedingly in color, in toughness, and in the ease with which it can be fused. And to what but an admixture with more or less of other minerals, can we impute these differences?

It seems to me, that in the present state of geological science, we may take it for granted, that compact feldspar has once been melted. But what was the original rock from which it was produced? Judging from the present constitution of the earth's crust, we must suppose that rock to have been one in which feldspar only predominated, but did not exist alone; or in some cases perhaps, the feldspar formed only a small proportion of the whole. The melting down of such rocks would produce just such varieties of compact feldspar as we find to exist. Sometimes they would be almost pure, while at other times they would contain so much silex, or other earth, that they could scarcely be distinguished from hornstone, jasper, quartz, &c.; and their fusion would be quite difficult.

Now it seems to me that there is too close a resemblance between this *a priori* reasoning and facts, to permit us to regard the former as mere hypothesis. It obviously gives us a clew to the whole history of compact feldspar, and prepares us to expect as great anomalies in its characters as can present themselves.

Compact feldspar in the vicinity of Boston forms deposits of considerable extent: I mean that variety which is so deficient in crystals of feldspar, that it would not generally be denominated porphyry. It is true, however, that a careful examination of this rock, will almost always detect these crystals in it; and sometimes polishing will bring to light a porphyritic structure where it was not previously obvious. Hence I have not hesitated to reckon compact feldspar as a variety of porphyry. The variety most wanting in feldspar crystals usually lies between genuine porphyry or sienite on the one side, and graywacke on the other. A deposit of it thus situated, extends from Medford to Malden. Another strip of it may be seen in the south part of Dorchester and Roxbury, and in the north part of Milton and Dedham. The same range, probably, appears and forms hills in Needham and

Natick. It is most likely the other extremity of this range that appears in Hingham. Often a portion of these deposits, especially on that side where they unite with graywacke, exhibits somewhat of a slaty structure; and when describing graywacke, I have mentioned a variety which is conglomerated compact feldspar. This was noticed near Neponset river, not far from the line between Milton and Dorchester.

Although the compact feldspar under consideration assumes almost every variety of color, yet there are certain predominant colors. One of the most common is a grayish white: as in Medford, where some of the rock has the aspect of granular quartz. This variety sometimes assumes a yellowish tinge, as in Newbury; and this appears to be one of the purest varieties of this rock, and the one, which, if any, will answer for Turkey stones. (No. 1206.) A dark gray color is another that prevails; and sometimes it is obvious that the rock embraces fragments of indurated slate, not perfectly incorporated with the feldspar. A more striking and very common variety is red, of various shades, from brownish to blood red. The latter variety abounds in Hingham, where ledges of it may be seen a little north of the village; and an interesting exhibition of it is made at the excavation for the Boston and Worcester rail road in Needham. Specimens of this rock can hardly be distinguished from the jasper so called, of Saugus; and probably it is essentially the same thing, viz. compact feldspar with a mixture of some other ingredients. Both of them are fusible with some difficulty into a semi-transparent porous glass. They correspond pretty nearly in their characters to the *rose petrosilex* of Sahlberg, described by Berthier in the 36th volume of the Annales de Chimie et de Physique, and which he regards as a distinct species from compact feldspar, and which Beudant has since described as such. However, it seems to me that if we make a distinct species of this variety, we must make a dozen others from the compact feldspar of Massachusetts. He would erect this into a new species, chiefly because it differs from feldspar so much in composition. But if compact feldspar had an igneous origin, should we not expect its composition to vary much according to the greater or less quantity of foreign substances that happened to melt and mix with the feldspar: nor would this be a reason for making distinct species, so long as the constituents of feldspar predominated. Some specimens of our compact feldspar of a reddish color exhibit traces of a schistose structure, and are even traversed by thin veins and layers of quartz. These melt with great difficulty.

These are the principal varieties of color that I have met with in the non-porphyritic compact feldspar of Massachusetts. When porphyritic, however, it exhibits several other predominant colors, which will be mentioned in the proper place.

2. *Antique Porphyry.* (*Porphyre antique, Al. Brongniart.*) This variety constitutes the great mass of the porphyry in the vicinity of Boston: and I call it antique because it so closely resembles that used in the monuments and ornamental furniture of the ancients. As to this point we have the testimony of Prof. A. Brongniart, who quotes 'Chelsea near Boston;' as a locality of porphyry, and says that 'it entirely resembles the antique porphyry.'* He might have added that probably as many, if not the same varieties occur in the vicinity of Boston, as were employed by the ancients. The specimens which I have placed in the collection, and the most of which are polished, will render this statement probable. For if I could obtain so many varieties during the little time that I have spent in examining this formation, how extensive a suite might be brought to light by long and careful research!

The compact feldspar that forms the base of these porhpyries presents numerous varieties and shades of color. One of the most elegant, is a light green, such as occurs in Chelsea and Malden; (Nos. 1254, 1256, 1257,) or the deeper green that I have met with in Milton. (No. 1255.) Red of various shades is a still more frequent color. (Nos. 1247 to 1253.) A reddish brown is sometimes met with. (Nos. 1240, 1241, 1243, 1258.) A nearly black color more often: (Nos. 1234, 1235, 1236.) A gray color sometimes: (Nos. 1239, 1242, 1244,) and a purple color rather seldom. (Nos. 1232, 1233.) The imbedded crystals are usually of a light color, sometimes white, sometimes brown, and sometimes greenish. Generally they are foliated, very rarely compact, and distinguished from the base chiefly by the color.

3. *Porphyry with a base of compact Feldspar, and two or more minerals imbedded.* (Nos. 1258 to 1262.) Feldspar and quartz are the two minerals present; but I have noticed usually small plates of mica. Sometimes it is very obvious, indeed, that this rock is intermediate between sienite and porphyry. In other words, it seems to be the former rock partly melted down into the latter. The porphyry of the Blue Hills is chiefly made up of this variety; though some perfectly formed porphyry is found there. The quartz is usually hyaline and smoky, and sometimes it forms the only imbeded mineral; the feldspar being all compact. In such cases especially, where the base is of a light color, the rock exceedingly resembles trachytic porphyry; (Nos. 1261, 1262,) and it will hardly admit of being polished for ornamental purposes. That a porphyry, which, by being thus associated so intimately with sienite, is proved to be one of the oldest varieties on the globe, should so much resemble the most recent variety, proves that similar causes have operated in its production at different and very remote periods.

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* Classification des Roches, p. 108.

4. *Brecciated Porphyry.* I know not how to describe this variety better, than by saying that it is composed of angular fragments of porphyry and compact feldspar, re-united by a paste of the same materials, which is itself also porphyritic. Hence it appears that there must have been an original formation of these rocks, (compact feldspar and porphyry,) which was subsequently broken up, either by the mechanical agency of water, or the mechanico-chemical agency of heat, redissolving and mingling the materials. The fragments are of various colors, usually, however, gray or red: and this proves that rocks from different localities must have been mixed together. The paste is commonly in the greatest quantity; and the rock is as hard and broken with as much difficulty as any other variety of porphyry. It is not a very common or abundant variety: but for ornamental purposes it affords specimens of great delicacy. (Nos. 1263 to 1270.)

Topography of Porphyry.

Only three ranges of this rock are given on the Map; and these are all in the eastern part of the State. Two of them,—the principal ones,—lie, the one on the north and the other on the south of Boston, having their longitudinal direction east and west. The third is in Essex county, extending easterly from Byfield Academy, nearly or quite to the coast. This strip is chiefly compact feldspar and mostly the red variety. It certainly deserves a more thorough examination than I have been able to give it.

In some places farther south, as for instance on the turnpike between Boston and Newburyport, in Topsfield, I observed a rock in place, intermediate between porphyry and greenstone: and not improbably genuine porphyry may be found in the vicinity.

This rock is most fully developed in its characters in the range a little north of Boston, extending from West Cambridge through Malden and Medford to the east part of Lynn. The southern border of this strip, certainly towards its western extremity, is compact feldspar. The porphyry (mostly antique, though sometimes brecciated,) forms a broken ridge of considerable height, generally naked and precipitous on its southern side. On the north it is succeeded by sienite, and the two rocks are so closely connected that the line between them is very obscure and irregular. I am satisfied, however, that this porphyry range has been usually represented too wide. This is the range that will probably furnish the best varieties for ornamental purposes, whenever the public taste shall create a demand.

There is reason to suppose that this range once extended much farther east than at present. For Hon. H. A. S. Dearborn informs me that Halfway Rock, lying in the ocean several miles east of Marblehead, is porphyry. Indeed, specimen No. 1264, which he presented to me, will show that it is the finest brecciated porphyry in the State, which I have met with. Now as this island lies nearly in the direction of the Malden and Lynn porphyry range continued easterly, I infer that it did once reach so far; (and perhaps does now beneath the ocean;) nor can we say how much farther. We see here from whence proceeded the porphyry pebbles that are so common along the southern shore of Massachusetts Bay, and on the islands of Nantucket and Martha's Vineyard.

The porphyry range south of Boston occupies much more of the surface than that just described; and yet I doubt whether it contains so much genuine porphyry. It extends with some apparent interruptions, (though I doubt whether there are any real interruptions,) from Natick to Hingham, through a part of Needham, Dedham, Milton, Braintree, Quincy, and Weymouth. I have not found it, however, in the latter place, and have marked the deposit of this rock in Hingham as insulated from the rest. This patch is chiefly compact feldspar. The range, it will be seen, embraces the greater part of the Blue Hills, the most elevated land in the vicinity of Boston, its highest point rising more than 700 feet above the ocean. But it is only the upper part of this mountain that is composed of porphyry, and by no means the whole of its summit neither: for sienite is frequently found there. The porphyry is chiefly that variety which has a trachytic aspect, being evidently intermediate between porphyry and sienite.

I have met with rocks approaching to porphyry in no other places in the State, except one or two. In the sienite of Whately I found a vein of compact feldspar two or three feet wide; but the foliated structure of the feldspar was not entirely obliterated. In the argillaceous slate of Guilford, Vt., a quite distinct porphyroid granite occurs, and with it well characterised greenish compact feldspar. These rocks are so obviously granite, imperfectly melted down, that I have thought it best to describe them under granite, and to place the specimens (Nos. 1467 to 1470) among those of granite. A specimen (No. 1211) of the Whately compact feldspar will be found in the collection.

Geological Position.

Of all the questions that have exercised the ingenuity of geologists, none appear to me more perplexing and unprofitable than those which they have raised and discussed relative to the primitive, transition, and secondary character of porphyries. In reading Humboldt's remarks on the transition of porphyries, in his Essay on the Superposition of Rocks, I have been reminded of a man benighted in a quagmire. Every effort which he makes to extricate himself, only plunges him in deeper. Am I asked whether the porphyry of Massachusetts belongs to the Primitive, Transition, or Secondary class? I reply that it belongs to none of them, but is a member of a series of rocks consisting of granite, sienite, porphyry, and greenstone, which have been protruded through, or among the stratified rocks, subsequent to their deposition. I say protruded: for if there be ground for making any theoretical inferences whatever in geology, it seems to me that it exists in this instance. The mere existence of these rocks, therefore, among those of any particular stratified class, does not prove that they were produced at the same epoch: it only proves that the unstratified rock was of subsequent production. On the other hand, if we find a stratified rock lying above others which are penetrated by veins of an unstratified rock, while this superior one is never thus penetrated, we may safely infer that it was deposited since the protrusion of the unstratified rock. These seem to be the two grand limits of our inquiries in respect to the ages of the unstratified rocks. And if this were all that is meant when the inquiry is made, whether they are primitive, transition, or secondary, a satisfactory answer might be given. In respect to the relative position of the porphyry of Massachusetts, however, I have but little to say, because but few facts have fallen under my observation. I have never met with an instance in which this porphyry was exhibited in juxtaposition with any stratified rock: except as already remarked, the compact feldspar succeeds to the graywacke as an older rock and gradually passes into porphyry. This porphyry, however, is associated, both on the north and south of Boston, with sienite; and in all cases, so far as I have observed, *the porphyry lies above the sienite*, and there is a gradual transition between the two rocks. This fact is most obvious in the Blue Hill range, where one is often much perplexed to decide whether the rock be sienite or porphyry. The sienite in these cases, however, it is important to remark, is never so far as I know, that variety consisting of compact feldspar and hornblende, which occurs as a member of the overlying family of rocks, but that variety composed essentially of feldspar, quartz and hornblende, which is connected with granite. Hence I infer that our porphyry belongs to the oldest varieties of this rock that have been described.

Mineral Contents.

Although in South America, according to Humboldt, porphyry forms the matrix of gold and some other metals, yet, in general this rock is remarkably destitute of foreign minerals. It is so in Massachusetts. In Malden it contains a little specular oxide of iron, and this is the only mineral hitherto announced as occurring in it. A careful examination of specimen No. 1222 with a microscope, has led me to the belief that it contains a minute quantity of native gold. The quantity is so very small that an assay cannot be made of it: yet it certainly bears an exact resemblance to native gold. The specimen is an extremely hard variety of compact feldspar approaching flinty slate, from the Blue Hills. I should not allude to this circumstance were not the porphyry of South America rich in this metal.

Theoretical Considerations.

Porphyry, or rather its base, has more the appearance of having once been melted than any of the unstratified rocks, except perhaps some of the vesicular traps. It has been thought by some distinguished writers that compact feldspar ought to be regarded as a mineral species distinct from common feldspar, chiefly because soda is found in it more frequently than potassa, and often exclusively. But one has only to examine the analyses of these two substances, to see that in this respect there is great diversity among both varieties. If compact feldspar is common feldspar or albite that has been melted in connection with other minerals, we ought to expect, as I have remarked in another place, that its composition would not coincide with that of common feldspar. And that it does result from this change in common feldspar, I can hardly doubt, when I often see specimens that have not entirely lost their foliated structure, being intermediate between the two minerals. And then the chemical effects that have been produced on other rocks in the vicinity of compact feldspar, (examples of which have been mentioned under greenstone,) clearly point us to an igneous agency.

I have elsewhere elucidated the argument in favor of the igneous origin of all rocks that are porphyritic, drawn from the chemistry of the subject. If that argument be valid, it is obvious that it will apply with peculiar force to the rock under consideration.

It is not uncommon to meet with specimens of porphyry that exhibit traces of an originally slaty structure in all or a part of the materials composing it. This clearly points us to a slaty rock as the source from which porphyry was derived. And sometimes fragments of this rock, along with fragments of compact feldspar, flinty slate, &c., are scattered through the mass as if partly melted down; very much as fragments appear in the slag of a furnace. They seem to be all but incorporated with the paste, and the whole mass presents an appearance of a more perfect chemical union than any rock resulting from aqueous agency ever exhibits, unless it be entirely crystalline.

Under what peculiar circumstances the matter composing porphyry was indurated, so as to prevent the greater part of the mass from assuming a crystalline state, it seems to me difficult to conjecture: and, therefore, I will not indulge in any speculations upon it. The gradual passage of this rock into sienite, without any apparent change of ingredients, seems to indicate that the peculiarities of porphyry did not result chiefly from the nature of the materials employed in its production.

17. SIENITE.

Most writers define classic sienite to be essentially composed of feldspar and hornblende: the first ingredient in the greatest quantity. It is essential also, that it should be connected with the overlying or trap rocks. This definition corresponds but to a small part of the sienite of Massachusetts. The greater part of it contains quartz as a constant and somewhat abundant ingredient, and mica is very often present. The most of our sienite is the granitic variety, and might perhaps have been described as sienitic granite. Yet in the eastern part of the State, it is very intimately associated with greenstone; and, therefore, I have thought it best to describe all the varieties of rock, between greenstone and porphyry on one side, and common granite on the other, into whose composition hornblende enters, under the name of sienite. Macculloch's definition, which he says 'alone rigidly accords with the common definition of sienite,' embraces the most important variety of our sienite: viz. a graniform mixture of feldspar, hornblende, and quartz. And this definition I shall take as the type of the rock now to be described.

The original specimen to which Werner applied the name sienite came from Sienna in upper Egypt, whence were obtained many of the Egyptian monuments, such as Cleopatra's Needle, Pompey's Pillar, &c. But this rock, it is now well known, is nothing but a red granite with black mica and a very small proportion of hornblende; a rock quite different from what Werner supposed. This mistake has occasioned almost endless confusion in geological descriptions. Roziere proposed a remedy. Ascertaining that mount Sinai in Arabia is composed of genuine sienite, he proposed to change sienite into Sinaite: but geologists have unfortunately neglected the hint.

Mineralogical Characters.

1. *Feldspar and Hornblende.* This differs from greenstone by the predominance of the feldspar: and yet it is obvious that in respect to many specimens, and even very large deposits, it is difficult to decide whether they should be referred to the former or to the latter rock. In almost all cases both the ingredients are

more or less crystalline: though sometimes, as at Nahant, the feldspar seems to be passing to a compact state. The hornblende is almost universally black; the feldspar white, greenish, and yellowish. (Nos. 1271 to 1285.)

I apprehend that by a careful examination of the specimens of this variety, nearly all of them would be found to contain more or less quartz: but quartz and feldspar, when seen through a microscope, resemble each other so much, that it is not easy to decide. At any rate, this variety insensibly admits quartz and mica into its composition, and thus approximates to granite. It is hardly necessary to say, that on the other hand it passes into greenstone. This variety, although elegant, is rarely wrought for ornamental purposes, on account of the proverbial toughness of the hornblende.

2. *Feldspar, Quartz, and Hornblende.* This variety embraces nearly all the sienite in the State that is employed for architectural purposes, including the quarries at Quincy and those on Cape Ann. Feldspar is the most abundant ingredient. This is foliated, and commonly of a grayish, bluish, or yellowish color. A hyaline quartz, varying in color from quite light to quite dark gray, is very uniformly mixed with the feldspar, so as to exhibit homogeneousness in the midst of variety. In general, the hornblende, which is black, is very sparingly disseminated, and hand specimens often contain not a particle. Indeed, over extensive tracts I have sometimes not met with any. Hence I regard this hornblende as an unessential ingredient; and consequently have arranged under this variety a rock very common in the vicinity of Boston, differing from that just described only by the absence of hornblende. It is most common a considerable distance south of Boston in the counties of Norfolk and Plymouth. In some instances, as may be seen by the specimens, Nos. 1286 to 1308, the feldspar is flesh red, or a liliac red, and in others of a blood red color. Its great resemblance in structure and composition to the Quincy and Cape Ann sienites, and the remarkable absence of mica, have led me to associate it with the variety under consideration: and in fact it forms a part of the same range. I distinguish this rock from granite only by the absence of mica: yet it must be obvious that this mark is not very satisfactory.

Sometimes the feldspar in this compound of that mineral and quartz, is nearly or quite compact. I have observed this variety most frequently in the north part of Essex county, as in Rowley and Newbury. A like compound is connected with the sienite of other countries.

3. *Feldspar, Hornblende, Quartz, and Mica.* In this quaternary compound we have a still nearer approach to granite. and generally it passes into granite by the disappearance of horn-

blende and the increase of quartz and mica. Yet in all cases where I have noticed it, this rock occupies a position between genuine granite and the newer stratified rocks. Hence I infer, that geologically considered, the difference between it and granite are important to be noticed.

The feldspar and hornblende are the predominant ingredients in this variety. The quartz is in so small grains that it is apt to escape notice; and the mica being usually black, is very easily mistaken for hornblende. In general all the ingredients exhibit a liveliness of crystalline structure which is observable only in the oldest rocks. The feldspar is ordinarily white, sometimes flesh colored, and the hornblende black. The grain of the rock is commonly finer than that of the 2d variety. As yet it has been but seldom employed for architectural purposes; although it would be beautiful and enduring. (1319 to 1340.)

4. *Porphyritic Sienite.* (Nos. 1341 to 1349.) I mean by this term any sienite through which are interspersed crystals or foliated masses of feldspar, so as to give the rock a porphyritic aspect. I do not recollect, however, ever having seen the last variety above described, porphyritic. And indeed, nearly all the rock which I regard as porphyritic sienite in Massachusetts, and specimens of which will be found in the collection, is almost entirely destitute of hornblende; and hence many geologists would regard it as porphyritic granite. But the specimens are rarely wanting in veins and disseminated masses of compact epidote, and I cannot but regard this mineral as more decidedly characteristic of our sienite than hornblende. If this be present and the mica almost or entirely absent, I have little hesitation in regarding the rock as geologically a part of a sienite deposit.

The most elegant variety of porphyritic sienite that I have met with in the State, occurs in Abington, and North Bridgwater, and in other parts of Plymouth county. Its base consists of quartz and feldspar, with an abundance of epidote disseminated and in veins. The feldspar crystals that constitute it a porphyry, are of a flesh color. There is also a dark colored mineral diffused through the mass, which may be hornblende or mica. This rock if polished would form it seems to me the most elegant ornamental stone in the State. (Nos. 1344 to 1347.)

The sienite of Cape Ann is often porphyritic. In one place, about half way between Sandy Bay and Gloucester Harbor, I found a variety in which the imbeded feldspar crystals are of a very rich bronze color, approaching in appearance to hypersthene. but when this rock is smoothed its aspect is too dark to be elegant. (No. 1343.)

5. *Conglomerated Sienite.* (Nos. 1350 to 1353.) This is a most interesting variety on account of the bearing which its char-

acters have upon the theory of the formation of sienite. I have met with it chiefly in the compound No. 3, just described. The rock in general does not differ from that variety; but it contains rounded masses of the oldest stratified rocks. It is in fact a real conglomerate; and in some places the nodules are so numerous that it has very much the aspect of the coarse pudding stones of the newer rocks. The nodules vary in size from the diameter of half an inch to that of six or eight inches. They are not smoothed, like the pebbles in the more recent conglomerates, by mechanical attrition: but they appear like masses of rocks that have been partly melted down by heat. In almost all cases hornblende predominates in these nodules: and often they consist of distinct hornblende slate. Sometimes they contain mica in considerable quantity, and more rarely they consist chiefly of quartz and mica, the former in excess, forming a kind of quartz rock. Feldspar is also frequently present, especially in those cases where the schistose structure is indistinct: and sometimes the nodule appears to be only a variety of sienite in which the feldspar is in a smaller quantity than usual. Upon the whole, I think I have ascertained the presence of hornblende slate, mica slate, and quartz rock, in these nodules. When the rock is broken they are knocked out without difficulty, like the pebbles from a common conglomerate.

The theoretical inferences deducible from these facts I shall reserve for the sequel.

6. *Augitic Sienite.* The presence of hornblende in this rock and the absence of mica, have led me to call it augitic sienite rather than augitic granite: although in position it is associated with granite. There are two varieties. The first is composed of black hornblende, greenish augite, and yellowish feldspar; all the ingredients except the feldspar exhibiting a very distinct and lively crystalline structure. This variety occurs in the northern part of Belchertown. The other variety, which I have found only in bowlders in Amherst, consists of augite and feldspar; the former being so arranged in the latter as to present the appearance of letters. (Nos. 1362, 1363.)

Topography of Sienite.

The eastern, and northeastern parts of Massachusetts most abound in sienite. A large part of Essex county is based upon it, as are several towns in Middlesex. On the south of Boston it spreads over a large part of Norfolk county and some part of Plymouth. A glance at the Map will show where it prevails most extensively. In all these places it forms hills of moderate elevation with no very striking characters. Its particular situation in respect to greenstone and granite I have already described in treating of the former rock.

The only other place in the State where I have met with sienite in place, is in the valley of the Connecticut. Here I have marked two deposits of considerable extent. The first extends from Mount Holyoke in Belchertown to Chickopee river and a little beyond: the other, on the west side of the Connecticut, occupies a considerable part of Northampton and Hatfield, and extends to the centre of Whately.

Although sienite very much resembling that which exists in the valley of the Connecticut occurs in the eastern part of the State, yet none like that which is so commonly employed for architectural purposes in the eastern part of the State, known as the Quincy and Cape Ann sienite, is found in the valley of the Connecticut. Nor have I met with any in that valley which is porphyritic. Indeed, I have arranged all which has come under my observation in that valley, under the quaternary compound described as the third variety in giving the mineralogical characters; although I doubt not but one or more of the four ingredients may sometimes be wanting. Perhaps all this sienite might properly be described as sienitic granite, or granite which takes a proportion of hornblende into its composition.

The sienite in the Connecticut valley occupies a low level, rarely rising into hills of more than 100 or 200 feet high. And on the west side of the river a considerable part of the formation is buried up by diluvium and tertiary strata.

The sienite of this valley sometimes exhibits a strong disposition to assume a columnar form. Perhaps this is exhibited no where to better advantage than in the ledge by the road side about a mile north of Northampton village. The columnar masses are only a few inches in diameter, and are much less perfect than those found in greenstone. The fact, however, is interesting, as indicating a similarity in the causes that produced the two rocks.

Pseudo-Stratification of Sienite.

At one of the quarries of this rock at Sandy Bay, Cape Ann, on the road from thence to Squam, a remarkably fine example may be seen of the division of this rock into parallel portions. Their thickness varies from two inches to two feet, and great facility is thus afforded for quarrying the stone.

As this apparent stratification extends only a few rods, while all the rest of the sienite on the Cape that I have met with, is unstratified, we cannot regard this case as real stratification. I consider it an example of the concretionary structure on a large scale. But it is unnecessary in this place to dwell upon this explanation, since I have already discussed it in treating of a similar phenomenon in greenstone.

Veins in Sienite.

These are numerous and various in their probable mode of production, as well as in their composition. Some of them might properly be denominated, 'veins of segregation:'* 'as they seem to have been formed by a separation of parts during the gradual passage of the mineral masses into a solid state.' In most cases they appear to consist only of harder portions of the rock, which become visible only by the weathering of the surface, when they are left in projecting ridges, and at a little distance cannot be distinguished from injected veins. I presume that it will be found in all cases, that these veins differ somewhat in composition from the rest of the rock: and indeed, in some cases this is obvious, as they contain more or less of a foreign mineral, such as epidote or quartz.

The greater part of the veins in our sienite consist of materials foreign to the nature of the rock, and introduced subsequently to its original production. I do not say subsequently to its consolidation: for it has appeared to me possible, that while a molten mass of rock, say sienite, was in an incipient state of refrigeration, matter of a similar kind, still more intensely heated, might have been injected into it so as to form veins. And the very near approach which some of the veins in sienite and granite exhibit to veins of segregation, has led me to the suspicion that they might have been produced in some such way, rather than by the filling up of open fissures subsequent to the consolidation of the mass of the rock. However, very many of the veins in our sienite were obviously produced in the mode last mentioned: for we find that lateral slides, sometimes of considerable extent, have taken place along the course of the vein; and this could not probably have been done till after a considerable degree of induration.

No substance is so common in the veins of our sienite as epidote. Yet the veins of this description are far less conspicuous than others, because they are so thin. Often they are easily mistaken for mere seams. The epidote is commonly very compact and resembles greenish compact feldspar: it has not, however, the toughness of that mineral, and it melts rather easily before the blowpipe into a black enamel. Sometimes the epidote of these veins is semi-crystalline and well characterised. I think that the lateral slides in the sienite mentioned above, occur more frequently in connection with these epidote veins than with any other.

The other substances composing veins in our sienite, are granite, feldspar, and quartz. The granite is most common: though generally feldspar is greatly in excess, and frequently no mica is present. Hence the vein, by a slight change, becomes entirely feldspar, ordinarily of a reddish hue. In one instance only, which has been already mentioned under porphyry, a vein two or three feet wide consisted entirely of compact feldspar. The quartz veins are frequently hollow and abound in delicate crystals of the same mineral.

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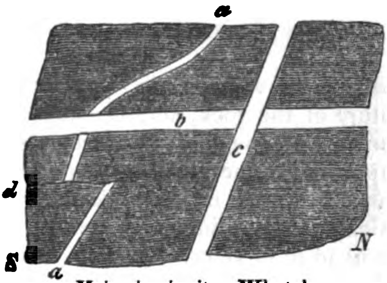
*Sedgwick's Anniversary Address before the London Geol. Soc. 1831, p. 3.

By far the most instructive exhibition of the veins that have been described, occurs in Whately, a mile or two a little west of south from the congregational meeting house. I subjoin a few sketches of those that struck me as particularly interesting.



Veins in sienite: Whately.

The above sketch represents an area about 10 feet long, and 6 feet wide. *aa,* Is a fine grained granite vein an inch wide at the upper end, and decreasing downward: *b,* another granite vein of fine grain, one foot wide: *c,* a similar one of equal width: *d* is a fissure, or rather an epidote vein.

aa, Is obviously the oldest vein; for it is cut off by *b,* and this again by *c.* Hence we have here granite and sienite of *four* epochs: 1st the rock of sienite itself: 2d the vein *a;* 3d the vein *b,* protruded subsequently: and 4th the vein *c,* injected last of all. At what epoch the vein *d* cut off *a, a,* we have no means of ascertaining; only that it was previous to the formation of the vein *c,* since this is not affected by the lateral slide apparent in *a, a.*

Macculloch says that 'there have been granites found where a vein of a *third* granite traversed a vein of a second and different one, which had previously traversed the mass of a first.'* The preceding sketch proves a *fourth* production of granite: for there can be no doubt but the sienite of Whately is a variety of granite. But if the suggestion above made, relating to the successive production of different granite veins, while yet the rock which they traverse was in a fluid or semi-fluid state, be admitted; we need not suppose any long interval between the formation of these veins. However, I do not place confidence enough in the suggestion to make it the foundation of any important inference.

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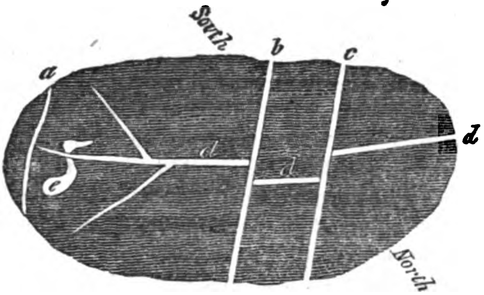
* System of Geology, Vol. I. p. 503.

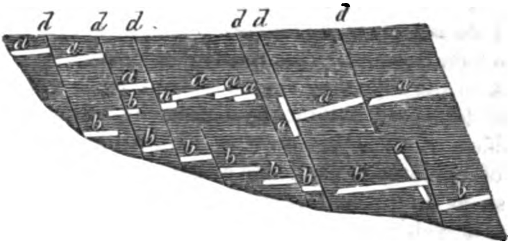
The rock in the following sketch is about 15 feet long. *d, d, d,* Is a vein of feldspar, two inches wide at its western extremity: but it ramifies at the other end and almost disappears. *a, b, c,* Are veins of epidote, on each side of which the sienite has become indurated so as to present ridges on the surface of the rock an inch or two in width; the epidote being a mere line in thickness. These veins have cut off the feldspar vein and produced an echellon movement of the central part. *e* Is a nodule of some other rock enclosed in the sienite and cut off by the feldspar vein.



Veins in Sienite: Whately.

We have here only two successive formations of granite, though the epidote veins were protruded at a third epoch. And the lateral movement of the sienite by these veins, indicates, it seems to me, that although the rock was consolidated at the surface, yet not probably to any great depth, when these epidote veins were injected; otherwise I cannot conceive how such a movement could have been produced. A slight heaving of the waters of a stream would break and produce various slides in the ice on its surface when it was quite thin: but let the river be frozen nearly to the bottom, and such movements would be produced with great difficulty.

The following sketch was formerly inserted in the 6th volume of the American Journal of Science: but such a curious succession of echellon movements have been produced in the granite veins, *a, a,* &c. *b, b,* &c. by the epidote veins, *d, d,* &c. that I thought it deserved a place here. The sides of the rock represented are about 4, 6 and 10 feet. *c* Is a fragment of some stratified rock imbedded in the sienite and cut through by the vein *b*. The width of the granite veins varies from one to 2 1-2 inches.



Veins in Sienite: Whately.

It is easy to conceive how the detached portions of these two granite veins might be brought into *alignment*, (to continue the allusion above made to military manœuvres,) but how they could have been thrown into their present position, except when the rock was in a fluid state, I am unable to conceive. And yet there must have been consistence enough in the veins to prevent their being diffused through the sienite. Does not this example lend some plausibility to the suggestion that has been made, relative to the protrusion of veins while yet the rock was in a partially fluid state? Or must we, in order to explain such a case as the present, suppose a second fusion of the rock?

Geological Position of Sienite.

I am not aware that any of the sienite of Massachusetts can be properly called an *overlying* rock: that is, I have found no example where it lies above other rocks. On one side it usually passes by insensible gradations into granite and on the other into greenstone and porphyry: or when these rocks are wanting, some of the stratified rocks, such as hornblende slate, graywacke, or new red sandstone, repose upon it. At least this is the impression I have received from all the examinations which I have made of our sienite; although I cannot refer to particular spots where these various rocks are brought into the relations that have been described. The low level at which our sienite is placed, has caused it to be very much covered with diluvium, so as to hide its junction with other rocks. Yet in all cases where this rock occurs, we find it between the oldest granite and greenstone, or the earlier stratified rocks. Hence I infer that a portion of the materials of which granite is composed, under certain circumstances were converted into sienite, and that these circumstances existed generally in that portion of the melted granite nearest the newer stratified rocks. Or if we suppose it erupted at a different epoch from the granite, certain causes always forced it upwards between the granite and the newer rocks. Or if we suppose it to have resulted from the melting down of the stratified rocks, then perhaps their more or less perfect fusion produced the difference which we find between granite and sienite. But more of this last suggestion in the sequel.

Mineral Contents.

The limits between sienite and granite, as well as between sienite and greenstone, are so vague and unsettled, that it is not always easy to ascertain to which of these rocks, minerals described by different writers belong; since in such a case geologists will be apt to give different names to the same rock. Genuine sienite, I mean that which is best characterised, is in Massachusetts rather barren of simple minerals: not quite so much so, however, as porphyry. By far the most common mineral is epidote; whose characters and mode of occurrence I have pointed out. The sienite used for architectural purposes from the vicinity of Boston, contains less of this mineral than any other variety in the State.

There is an interesting variety in the feldspar of this rock. In Beverly a few years since, a considerable quantity of green feldspar was obtained from a rock near the centre of the place. The bronze colored feldspar of Cape Ann has been already described, and that which is of a lilac color in Hingham. In Charlestown a a variety occurs in which the prisms exhibit stripes of various colors, and some have proposed for it the name *taenite*, on account of its resemblance to a ribbon. On Holyoke and Tom I have described a variety of trap in which this mineral presents a similar appearance. According to Professor Webster, hypersthene occurs in the sienite of Hingham along with hornblende. Amethyst is said to exist in the same rock in that place.

In the sienite of Beverly, fluate of lime and zircon have been found; and the former mineral in the rolled masses of this rock in Seekonk. In that of Charlestown Prof. Nuttall discovered arragonite. Prehnite, according to Prof. Webster, of superior excellence, is found there in the sienite: and that gentleman has recently informed me, that he has discovered in the same rock very superior specimens of chabasie and laumonite.

'I have the satisfaction to state,' says Dr. C. T. Jackson, in a letter lately received, 'that I have found a vein in the sienite of Cambridge, consisting of calcareous spar, serpentine, prehnite, laumonite, and chabasie. The three last occur in very handsome specimens crystalized. The calcareous spar occurs crystalized generally in the form of dog-tooth spar. It is of a honey yellow color and is very brilliant.'

The veins of quartz abounding in delicate crystals in the sienite of Northampton and Whately, have been mentioned. Associated with these, I have sometimes found a mineral crystalized in four sided prisms, which I have been disposed to refer to red oxide of titanium. The best place for obtaining these minerals, particularly the quartz, is in Whately, about two and a half miles south of the meeting house. Some of the drusy surfaces of this quartz present a curious pseudomorphous appearance. (No. 1369.) It is precisely such an appearance as would result from making random cuts in the quartz, while in the state of a paste, with a thin bladed knife. Obviously it has proceeded from the infiltration of the quartz around some mineral in thin plates, originally occupying the cavities, and subsequently decomposing.

Following the eastern margin of this sienite about a mile south into Hatfield, from the locality just mentioned, we find a vein of sulphate of baryta, from one to four feet wide, running by the magnetic needle W. 22 1-2° N., and dipping about 90°. This baryta is the gangue of the sulphuret of lead, blende, and pyritous copper. It has been excavated several feet, and the quantity of baryta thrown out was immense.

Since the publication of the first edition of this Report, I have received from Sandy Bay, in Gloucester, Cape Ann, well characterised specimens of sulphuret of molybdenum. It is in plates in a vein of quartz running through sienite.

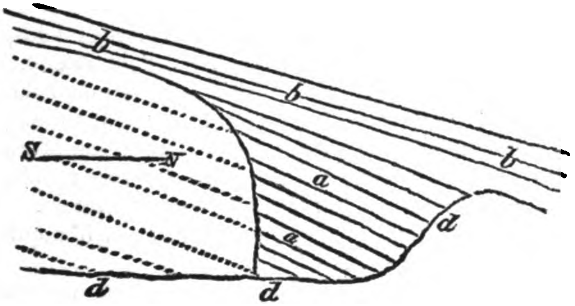
Theoretical Considerations.

Sienite is very rarely found in Massachusetts in continuous veins in other rocks like granite and greenstone. Sometimes, however, as I have formerly stated, it penetrates sienite of a different variety, or greenstone, in so many directions and in such large quantity, that the rock so penetrated is divided into numerous fragments forming a kind of breccia. Even in these cases, the sienite which thus forms veins, contains but little hornblende. Upon the whole the argument in favor of the igneous origin of sienite from the mechanical or chemical effects of its veins, is comparatively feeble.

In the conglomerated sienite which has been described, however, I think we have a peculiar and forcible argument in favor of the former fusion of this rock by heat. Some other theoretical inferences also result from the facts in this case, which will need more minute details than have yet been given.

I have frequently observed this variety of sienite in the eastern part of the State. But there the nodules are so much changed in their characters that they seem to be only a variety of sienite. It is in the valley of the Connecticut that the most interesting and striking facts on this subject are developed; and in that valley Whately is the place that most particularly claims attention. The following imperfect sketch will give an idea of the situation of the conglomerated sienite there. It is the northern point of a range extending through Hatfield and Northampton southerly: and it here abuts against a limited deposit of hornblende slate, whose strata run nearly N. E. and S. W. as *a*, *a*, and stand nearly perpendicular to the horizon.

This slate is succeeded on the west by mica slate, *b*, *b*, *b*, which indeed, sometimes alternates with the hornblende slate. On the eastern side *d*, *d*, *d*, the sienite and the slate are covered by the diluvium and new red sandstone of the valley of the Connecticut. The sienite and hornblende slate are elevated not more than 100 or 200 feet above the general level of that valley: but directly west of these rocks the mica slate rises more rapidly into ridges of much greater elevation, forming the eastern margin of the broad range of the Hoosic mountain.



Now I have been led by an examination of the spot just described, (whose length is 3 or 4 miles and breadth less than one,) to conclude that the sienite was formed by the melting down of the hornblende slate. I infer this chiefly from the fact that this rock, as has been described, contains nodules of this slate, appearing as if rounded, not by mechanical attrition, but by heat. Why it should happen that the fusion of this slate should give rise to the production of feldspar, we may not be able fully to understand. And yet, if we suppose the hornblende slate to be composed of hornblende, mica and quartz, as it sometimes is in Whately, or that it alternates with mica slate, as it does there, we shall have in the materials melted down, all the essential ingredients of feldspar, viz. silex, alumina, and potassa. A certain degree of heat may be all that is necessary to enable these elements to enter into the new combination that is necessary to the production of feldspar. At any rate, I think I am not mistaken in the fact, that as the imbedded nodules in the slate approach more nearly to sienite in their characters, and recede from those of slate, the greater the quantity of feldspar. What can this circumstance result from, but from the greater degree of heat to which such nodules have been subject? Their losing in so great a degree the slaty character proves that they have been more nearly melted.

Another circumstance lends in my opinion a plausibility to the preceding suggestions. Towards the northern extremity of the hornblende slate above described, and at least a mile distant from the sienite, we find the slate composed of compact feldspar and hornblende; and its schistose structure almost obliterated. There is also a tendency in the rock to divide into columnar and rhomboidal forms. Now in these facts we see, it seems to me, the effects of a heat sufficient to produce a partial fusion of the rock, but not an entire obliteration of the slaty structure: sufficient for the production of feldspar, but not for its crystalization. All this indicates a source of heat of great power at a small depth where probably genuine sienite exists.

There is another fact which I have noticed in one portion of this sienite, that lends still farther support to these views. Two miles south of the spot where the sienite and slate meet, I observed the traces of an obsolete stratification in the former rock, running in the same direction as the basset edges of the slate, indicated on the preceding sketch by dotted lines. There is no actual division of the sienite into parallel portions but only the marks of a former division by a sort of segregated ridges. The existence of the nodules of slate in the sienite proves that the fusion of the rock was never complete; and in these faint traces of original stratification do we not see evidence of the same fact; and in the coincidence of direction between the strata of hornblende slate and these marks, have we not presumptive evidence of the origin that I have imputed to the sienite?

These various facts and inferences have led my own mind to make another inquiry. Do we not here see the reason why one part of a deposit is sienite, and another part granite; that is, a rock destitute of hornblende? When the fusion of a rock is complete and the heat carried to a certain degree, may not the production of hornblende become impossible, because those affinities and polarities operate that produce other minerals, especially feldspar and mica? The sienite in the valley of the Connecticut at least, occupies a position generally between the granite and the newer stratified rocks. And if we suppose the heat to have been greater at the time of the production of these rocks, in proportion to the depth beneath the surface, it is obvious that it must have been greater where the granite was produced, than where the sienite is now found. For even if we do not suppose the sienite to have resulted from the fusion of stratified rocks, yet the proximity of its materials to these rocks must have greatly reduced the temperature of these materials: and if the stratified rocks were melted to form it, still more certainly would such be the result. Whether the position of sienite in other parts of the world is similar to that in the place under consideration, I know not; nor can I say whether that in the eastern part of Massachusetts will throw any light upon these speculations.

This suggestion, as to the ground of difference between sienite and granite, derives some support from the great scarcity of crystalized minerals in the former, compared with those in the latter. I can imagine no cause for this difference so probable, as a more or less perfect fusion of the materials. The history of porphyry leads the mind to the same conclusion.

These hypothetical views I am aware are new. But I have been led to form them from the facts that have been detailed; and if they are thought by geologists to deserve consideration, I hope that facts derived from other deposits of sienite and granite will be brought to light to prove their fallacy or correctness.

18. GRANITE.

Having included under sienite all those unstratified granitic compounds which contain hornblende as a constituent, the definition of granite becomes easy. It is, indeed, the common definition, which makes it to consist of quartz, feldspar and mica. Dr. Macculloch adds hornblende: but it seems to me that this destroys the usual distinction between granite and sienite. Granite may, indeed, contain disseminated crystals of hornblende, as of garnet, pinite, or any other mineral: but if the quantity of this hornblende is so great that it must be regarded as a regular constituent of the rock, I do not know why it should not take the name of sienite, unless we should merge all sienite in granite: and to this I have no objections. I can conceive, indeed, how the geological relation of granite with hornblende, may be such to granite without hornblende, that it would be preposterous to attempt to separate them: but I know of no such case in Massachusetts. Here sienite occupies, as we have seen, a constant geological position in respect to the granite about to be described.

Mineralogical Characters.

1. *Common Granite.* This variety embraces nine tenths of the granite in Massachusetts. All those compounds of quartz, feldspar, and mica are included in it, which differ only in the size of the ingredients, in the greater or less perfection of their crystalline structure, and in their color. In these respects they do differ almost infinitely, as may be seen by the numerous specimens from various parts of the State in the collection. (Nos. 1372 to

1461.) Generally the quartz is gray, sometimes smoky, sometimes blue, and sometimes yellow. The feldspar is ordinarily yellowish white; sometimes green, as in Southbridge; sometimes blue, as in Leverett; sometimes tinged with purple, as in Palmer; and more often flesh colored, as in the coarse granite found in Blanford, Westfield, Amherst, &c., and in the finer grained granite in the southeast part of the State. The mica is more commonly of a silver color; sometimes of a straw or gold yellow, or greenish; sometimes of a brown color; sometimes black; sometimes rose red; and sometimes it is prismatic, as in Russell and Norwich.

In magnitude the ingredients vary from that of masses one and even two feet in diameter, to those so small that they can be distinguished but with difficulty by the naked eye. Those granites that possess a fine grain are the only varieties that are employed for architectural purposes. The coarsest varieties are generally found in veins.

2. *Pseudomorphous Granite.* This is a variety that exhibits a structure so peculiar that I have thought it deserves a distinct notice. Suppose the quartz and feldspar requisite to form a coarse granite to be united into a solid mass. Suppose the mass to be now penetrated in various directions by the blade of a thin knife, and the cavities thus produced to be filled by plates of mica not more than one fiftieth of an inch thick. Although these plates would form solid angles, they would not intersect one another; and so it is in the rock. The smallest fragment of the quartz and feldspar are often separated by the mica; but I have never seen one plate of that mineral intersect another. The solid angles which these plates form in the quartz and feldspar, however, appear like the projecting angles of crystals, and hence I have applied to this granite the term pseudomorphous. The mica is usually of a deep bronze color and often the plates are four or five inches across. (No. 1462.)

3. *Porphyritic Granite.* (Nos. 1463 to 1470.) In this variety, besides the ingredients composing the mass of the rock, and which are quartz, feldspar, and mica, distinct imbedded crystals of feldspar are superadded. In Europe the basis of this rock is said to be fine grained: but in Massachusetts it is more commonly rather coarse grained.

Perhaps the most remarkable porphyritic granite in the State occurs in place in the west part of Harvard. (No. 1465.) It is a gray rather coarse granite with white feldspar, and the imbedded crystals are often two inches across; and being white, they give to the rock a striking appearance; and it has actually been mistaken by some writers for a conglomerate!

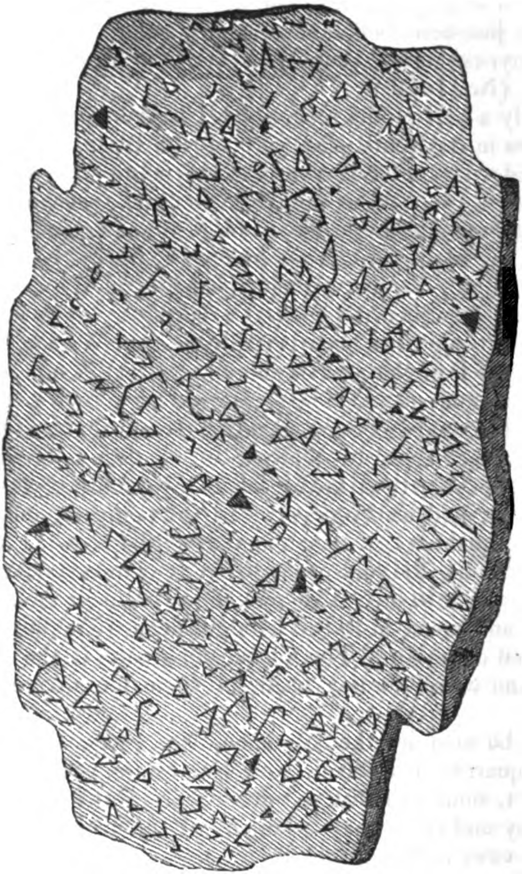
In Chester a large protruding mass of granite in the west part of the town is porphyritic. The imbedded crystals are much less than those just described, and of a gray color. The rock resembles porphyritic gneiss; but lacks both the laminar and stratified structure. (No. 1463.)

Probably a part of the rock which I have described as porphyritic sienite in the south east part of the State, as in Abington, North Bridgwater, Fair Haven, &c. may more properly be regarded as granite. Indeed, as this rock is usually destitute of hornblende, perhaps the whole should be regarded as granite.

A very peculiar porphyritic granite occurs in the argillaceous slate of Guilford, Vt. just without the limits of Massachusetts. I should have described this rock as a porphyry, were it not obviously a granite that has been partially fused. We can easily trace the gradations from the perfect granite to a rock composed of compact feldspar and imbedded masses of quartz. (Nos. 1467 to 1470.) At first we perceive nothing peculiar, except that the granite exhibits occasional spots of feldspar of nearly a milk white color, and a little indistinctness in the foliated structure of the feldspar. At length the feldspar becomes nearly all compact, and the mica, reduced in quantity, is disseminated in the mass as well as the quartz. Finally, the feldspar is perfectly compact and only grains of quartz appear in it. The rock now begins to assume a slaty structure, and seems in fact to be argillaceous slate that has undergone a kind of fusion. The unchanged granite in this case is fine grained, and would form a beautiful stone for architectural purposes.

It may be seen by the specimen, No. 1455, that the granite from the quarries in Pelham, New Hampshire, exhibits a porphyroid aspect, similar to that just described. But I have not visited the locality and cannot say whether all the circumstances above described exist in that place.

4. *Graphic Granite.* (Nos. 1471 to 1480.) In this variety, which consists of quartz and feldspar only, the ingredients are usually in lengthened prisms, so that the cross fracture presents the appearance of written characters. It is the Pegmatite of the French geologists. Dr. Macculloch thinks it occurs exclusively in veins. But that is not the case in this country, unless every protruding mass of granite be regarded as a vein. In the coarser varieties of our granite, a portion of the mass—generally a small proportion—is graphic: and there is no well marked line of distinction between the varieties. This is particularly the case in respect to the pseudomorphous granite, so common in Conway, Goshen, Williamsburgh, and Westhampton. In Goshen a few years since, I found a specimen which afforded so perfect an example of the graphic arrangement in this rock that I thought it deserved to have its surface copied.



Fac Simile of Goshen Graphic Granite.

Topography of Granite.

Probably there is not a town in Massachusetts in which more or less of granite does not occur, either *in situ* or as bowlders. And no rock is probably so generally known as this: though the term is often very loosely applied.

To begin with the eastern part of the State: it will be seen by the Map that granite lies between the sienite on one side, and mica slate and gneiss on the other, nearly across the State, from Andover to R. Island. Generally this granite is coarse, and it forms no hills of much altitude. Obviously it has been powerfully abraded by currents of water. In elevation it is intermediate between the greenstone on one side, and the gneiss on the other; that is, as we pass from the coast westward, we gradually ascend; rising slightly from the alluvium to the graywacke; still more as we come upon the greenstone and the sienite; still more to reach the granite, and still more in the region of gneiss. The height of land between the ocean and Connecticut river, is not attained till we pass west of the valley of Worcester. A glance at the sections accompanying this Report will render these statements obvious. (Plates XVII and XVIII.)

The southern part of the range of granite above spoken of, is fine grained and passes into sienite, especially in Rhode Island. In the vicinity of Providence it is extensively wrought for architectural purposes. The splendid columns of fine grained white granite in the Arcade in that city, were obtained from a quarry in Johnstone, 5 miles northwest of Providence. 'They are twelve in number,' says Dr. Webb, 'cut out of solid blocks, 21 feet long, 3 feet in diameter at the base, and weigh 11 tons each. It required 11 yoke of oxen to draw each one into town. It is calculated that it would have taken one man upwards of six months to have wrought one of these columns. The stone for the first five locks of the Providence and Worcester canal, was also obtained from this quarry.'

The broad deposit of granite marked between Narraganset and Buzzard's Bays, consists chiefly of the common varieties. Much of it is extremely coarse. But in some places, as at Fall River in Troy, the grain is fine and the rock well adapted to architecture. Along the western border of this range the rock appears in place in great abundance; but as we pass easterly, the surface is almost entirely covered with bowlder stones, mostly of granite. On its northern margin, however, where we approach the graywacke, the loose blocks of this latter rock are so accumulated upon the granite, and the country is so nearly level, that it is impossible to ascertain the limits of the two rocks. As we go easterly into the region of the Middleborough ponds, the difficulty increases; and I have put down an extensive patch of diluvium in that quarter on this account. In the vicinity of New Bedford and Rochester the same difficulty has perplexed me in ascertaining the limits between granite and gneiss. Nor shall I be disappointed if the lines which I have finally settled upon should need material alteration.

It will be seen that I have connected the Fall River range of granite on the east, with the sienitic granite in Cohasset, Hingham, &c. Two facts have led me to do this. In the first place, as we pass from Marshfield through Pembroke, Plympton, and Carver, to Wareham, we do occasionally meet with a ledge of granite: and secondly the bowlder stones are nearly all granite. It will be seen, however, that a great part of this region I have marked as diluvial.

The Map will show, also, that I have extended a strip of granite from Plymouth into Barnstable county as far east as Brewster, and carried another branch into Falmouth. These ranges follow the highest ridges in the south part of Plymouth and in Barnstable counties. And although in no part of these ridges, with one or two exceptions, have I found rocks in place, yet such is the size and number of the bowlders as to satisfy me that they have never been far removed from the parent rock; and I cannot but believe that ledges do exist a little below the surface; and not improbably in some places, which have not fallen under my notice, they may be found at the surface. Where first Cape Cod commences, and nearly half way between Sandwich and Falmouth, appearances are peculiarly indicative of granite ledges: and they continue nearly to the village of Falmouth. As we go eastward they are less striking, until we reach the town of Brewster, where, as I have shown under diluvium, there is reason to suppose the shattered crest of a ledge appears.

I am aware that it would have been accordant with truth to have colored the whole of Cape Cod as diluvial. But my rule has been not to exhibit that stratum when I could ascertain the rocks beneath it. Others must judge, whether the evidence of the existence of granite in place, in the region under consideration, is probable enough to justify me in the course I have taken.

That gneiss range in the central parts of the State, which lies east of the Worcester mica slate, abounds in veins and protruding masses of granite: but I have thought it useless to attempt to represent them on the Map. My opinion is, that in going easterly the granite increases in quantity until the gneiss and mica slate at length disappear.

The Worcester range of mica slate contains numerous large beds of protruding masses of granite; some of them of great interest, on account of their adaptedness to architectural purposes. It must not be expected, however, that in all cases a deposit of granite will be found in the precise place where one is marked on the Map, in this mica slate. In Worcester the spot thus colored is intended to mark out the true situation of an interesting deposit of granite: the only one which I have discovered in the southern part of the mica slate. The spot in Harvard, also, represents a deposit of remarkable porphyritic granite. In Westford, Lowell, and Tyngsborough, the spots colored as granite, indicate only that numerous masses protrude in that vicinity. In Pelham, N. H. I intended to mark the bed which is now extensively quarried. In Pepperell, Townsend, and Lunenburg, I intended only that the beds marked should stand as the representatives of numerous veins and masses in those towns. The same is particularly true of the spots marked in Leominster and Westminster. In passing from the former to the latter place, granite is very abundant: and the mica slate, sometimes for a considerable distance, disappears. A spot marked in the south part of Fitchburg, is intended to designate the large hill of granite that furnishes so fine a building stone in that town.

Except in the northwest part, I have colored no spot as granite in the extensive range of gneiss in Worcester county. That it exists elsewhere I doubt not: as on the top of the hill in Spencer, where one sees the granite obviously protruding through the pseudo-gneiss strata: but I believe that much, which in that range has been called granite, is nothing but granitic gneiss. It is only after long experience in examining these rocks, that the difference is perceived between granitic gneiss and real granite.

In the northwest part of this gneiss range, especially in the lower part of N. Hampshire, we find the gneiss changing into mica slate, with occasional masses of considerable extent of fine grained granite, generally excellent for economical purposes. The beds of granite and mica slate which are there marked, are not intended to represent the exact relative position and quantity of the three rocks, but only to show that such a succession of strata is found there, and that the mica slate and granite occupy a large proportion of the surface.

The narrow range of granite extending from Amherst to the north line of the State, occupies an intermediate level between the alluvial bottom of the Connecticut valley, and the high ridge of gneiss bounding that valley on the east. It is an extremely coarse granite, and for the most part occurs in the form of veins or irregular masses in mica slate and gneiss. And in some places these rocks very much predominate and we lose sight of the granite.

The patch marked as granite in the argillaceous slate of Guilford, Vt., has been described in giving the mineralogical characters of this rock. I would add, that the beds are somewhat numerous, although but one is represented on the Map. The deposit in Chester has also been described. The range extending from Conway into Connecticut, alone remains to be noticed. This occupies the space between the sienite on the east, and the mica slate on the west. More or less of the slate is intermixed with it through its whole extent; and on the west, and towards the south, this slate abounds and predominates. The strips of mica slate running into the granite, are intended merely to indicate the fact that they do thus penetrate it, rather than to give an exact representation of the particular places where this takes place.

For the most part the granite of this range is very coarse. Not unfrequently, however, very coarse and very fine granite are associated. In the granite patch extending from Norwich to

Chesterfield, (and which implies only that beds are frequent in that region,) the rock is coarser than any that I have found in the State; the plates of mica being sometimes a foot or a foot and a half across. It is these coarse granite veins that are most prolific in minerals of an interesting character.

For the most part this granite range occupies a low level: or rather it is intermediate between the lowest and the highest of the rocks on the western side of Connecticut river. Some of the granite hills in Conway, Williamsburg, Whately, and Westhampton, rise higher than any others of the same rock in the State. Their altitude, however, is only a few hundred feet; and is far inferior to the hills of mica slate lying immediately to the west.

Upon the whole, all the granite in Massachusetts lies remarkably low in respect to other rocks; and one cannot avoid the inference when he examines its situation in almost all cases, that the abrasion of the stratified rocks may have brought the granite to light.

In the conglomerate of the new red sandstone, at the south end of Sugar Loaf mountain in Deerfield, many of the nodules consist of a delicate variety of flesh colored graphic granite. Whence it originated I am unable to conjecture.

Pseudo-Stratification of Granite.

I have met with but one distinct example of this peculiar structure in the State: but it is a case of peculiar interest. It occurs in the patch of granite marked in Worcester. It occupies the hill, 200 or 300 feet high, a little northeast of the village. The rock is composed almost entirely of gray quartz and white foliated feldspar, with very little mica, and hardly differs from the sienite of Cape Ann and Quincy; although entirely destitute of hornblende. It is quarried in various places on the sides and top of this hill, and in several of the excavations it exhibits a very distinct stratification. It is also crossed by numerous seams, nearly perpendicular to the horizon, not having any uniform direction; and generally the apparent strata do not correspond on opposite sides of the seams. This seems to result from their elevation or depression on the opposite sides. I satisfied myself, however, that the pseudo-strata conform on all sides nearly to the slope of the hill, being horizontal at the apex, and extending over the sides like the coats of an onion. If this be a fact, it shows conclusively that this hill of granite is an enormous concretion. The concentric layers, however, do not extend to every part of the hill: and this fact proves that there is no real stratification in the rock.

Phenomena of Veins and Irregular Protruding Masses of Granite.

The only modes in which I have met with granite in Massachusetts are those of veins and protruding masses. In some instances regular masses with parallel planes are seen between the strata of other rocks; and on a superficial view, seem interstratified. But careful examination has always shown me, that such masses either cross the strata in a slight degree, or contract and expand like veins: and seem indeed to be veins coinciding nearly with the strata of the contained rock in direction. I can hardly say that I have met with granite as an overlying rock, though a few cases, which will be described farther on, exhibit this rock in a near approach to such a condition.

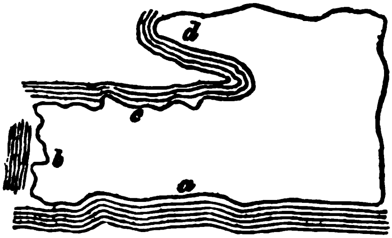
The veins of granite in Massachusetts penetrate only the older rocks; the clay slate being the latest in which they are found. All the older stratified rocks abound in them; though in quartz rock I have rarely met with any. In gneiss they are very common, especially in the gneiss range east of the Worcester county mica slate: also in the vicinity of New Bedford: and in the southern part of the gneiss range in Hampden and Berkshire counties. Mica slate is penetrated by them and broken up by protruding masses of granite, at almost every step, in the granite range on the west of Northampton, particularly in the towns of Westfield, Blanford, Russell, Chester, Norwich, Williamsburgh, Westhampton, Goshen, Chesterfield, Whately, and Conway. In talcose slate they are very rare: in hornblende slate not common: in micaceous limestone sometimes met with: in serpentine I have never found one. In granite and sienite they are very abundant: and almost always the ingredients are much coarser than the granite or sienite that contains them.

For eight or ten years past I have been in the habit of taking rough sketches of those spots which I have met with, where granite veins and protruding masses exhibited any peculiarity which I supposed might be interesting to geologists. Of these cases I shall now give an account. I doubt not but a very great number besides these might be discovered by careful research. But to search them out requires a great deal of labor and patience.

It ought to be premised, that in a large majority of cases, the intrusion of granite veins seems to have produced very little disturbance in the rocks containing them. They would seem to have been open fissures filled by the injection of granitic matter, without materially affecting the walls, except to unite with them chemically. And the same is true to some extent in regard to irregular masses of granite: that is, we do not always see any alteration in the dip and direction of the strata in the immediate vicinity of the granite. Yet in such case we usually find not far distant, an irregularity in the position of the stratified rock.

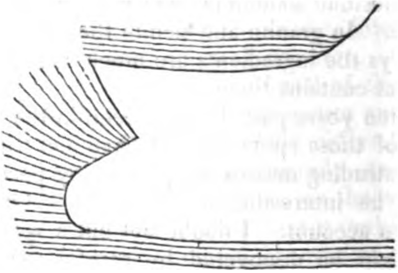
In giving the details which follow, it will not be easy to state beforehand any definite order that will be adopted. The most that I shall attempt will be to bring into juxtaposition those cases that are analogous.

The sketch below represents the manner in which the edges of the mica slate lie in contact with a protruding mass of granite in the south part of Conway.* At *a*, the slate runs north and south and dips east: at *b*, it dips south: at *c*, west: and at *d*, southeast. The sketch embraces an extent of only a few square rods.



(1) Junction of Granite and Mica Slate: Conway.

No. 2 exhibits a similar case near the village of Blanford, close by the road to Granville. The mica slate here runs nearly north and south, and dips 80° west: except at the end of the mass of granite, where the dip is nearly north, about 70° or 80°.



(2) Junction of Granite and Mica Slate: Blanford.

The following case I noticed in the west part of Leominster; where the numerous veins and masses of granite in the mica slate, and the great confusion obvious in the latter, made me desirous to spend more time in examining the surrounding region than I was able to do.

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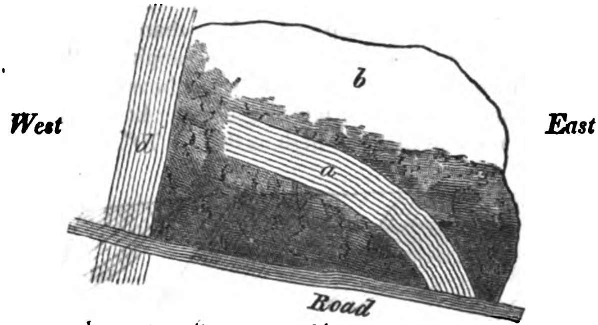
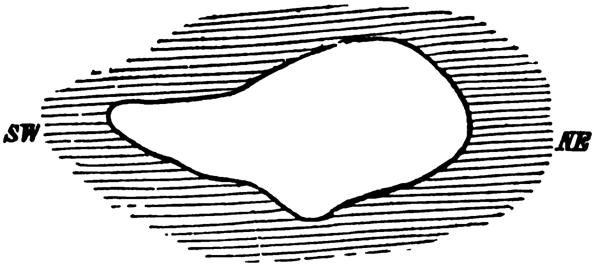
* In all the following cases the uncolored part of the sketch represents granite; except that in a few cases (ex. gr. No. 9.) irregular lines are drawn to represent the irregular divisions of granite.



(3) Junction of Granite and Mica Slate: Westminster.

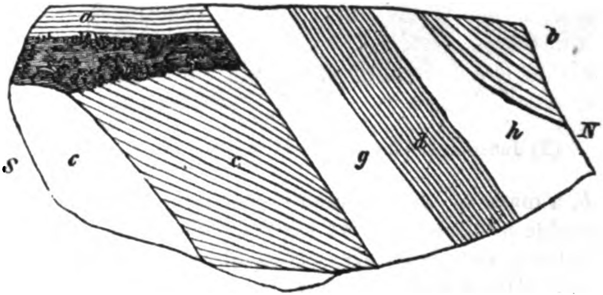
At *b*, a mass of coarse granite occupies the top of a hill of considerable altitude. As we approach the road, descending from the hill, the granite is mostly concealed by diluvium. At *a*, however, mica slate appears running nearly east and west. A few rods to the west at *d*, it runs nearly north and south; which is the usual direction of the slate in that region. What but the disturbing force of the granite could have turned the mass *a*, nearly 90 degrees?

No 4 exhibits a protruding mass of coarse granite 20 or 30 rods long in mica slate. The slate does not seem to be disturbed. It has an easterly dip of about 80°. The sketch was taken in the northwest part of Norwich.



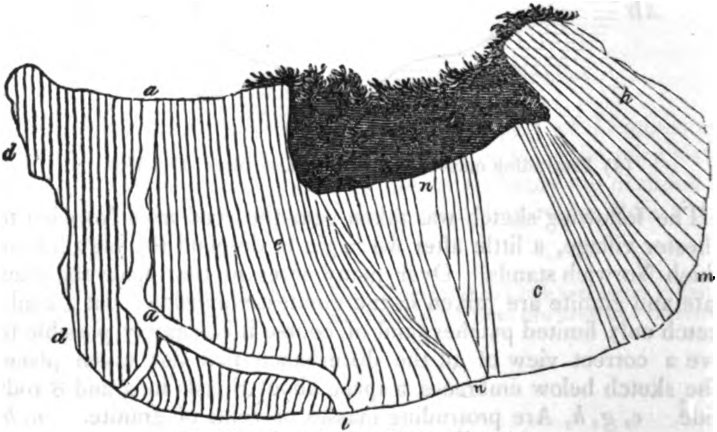
(4) Protruding mass of Granite in Mica Slate: Norwich.

The following sketch was taken near the road from Norwich to Chester village, a little after we begin to descend the high hill on which Norwich stands. Over many acres in that place the mica slate and granite are mixed in the greatest confusion: but I could sketch only limited patches, and of course it is scarcely possible to give a correct view of all the disturbance that has taken place. The sketch below embraces a space about 8 rods long and 3 rods wide. *e*, *g*, *h*, Are protruding masses or veins of granite. *a*, *b*, *c, d,* Show the basset edges of mica slate. At *a,* its strata run nearly north and south and dip rather less than 45° to the west: which is the usual dip and direction in the vicinity. At *b,* and *c,* the strata are turned so as to run nearly northeast and southwest; but the dip is increased only a few degrees. At *d,* they are still more wheeled, and the dip is as high as 60° or 70°.



(5) Granite and Mica Slate: Norwich.

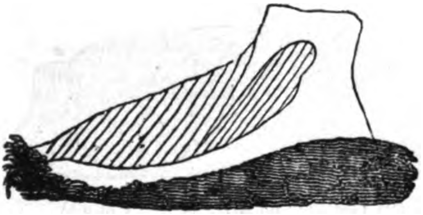
The next case is at the same place, and embraces a space about 16 rods long. *a, a, b, n, n, m, m,* Are veins of granite from one to two feet wide, and *c,* a mass 10 feet wide. A large mass also lies on the side *d, d.* At *h,* the mica slate is deflected only a few degrees from the usual course of its strata, which is nearly north and south. The dip there is 45° northwest. But in every other part of the sketch, it will be seen that the mica slate is turned almost at right angles to its usual course, and towards the lower part of the sketch it exhibits most remarkable curvatures. The dip also, is in general greatly increased; so that in the vicinity of *e,* it is 80° north.



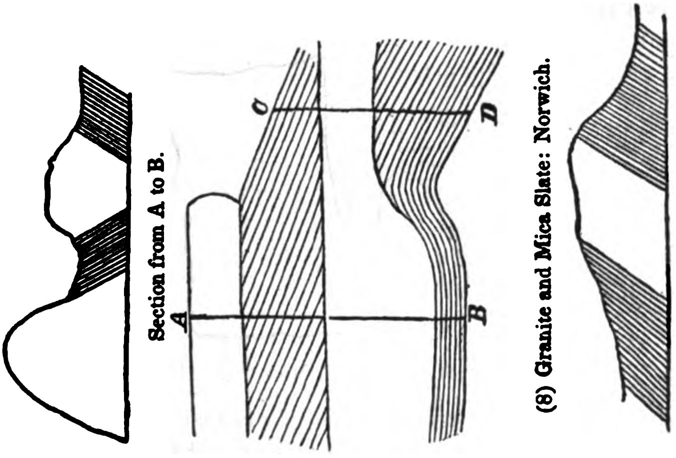
(6) Granite and Mica Slate: Norwich.

I feel the inadequacy of such sketches to convey a just idea of the very great confusion which this spot exhibits. But if any one can examine such places and still maintain that granite was not forced up through the slate while in a fused state, I can only say that his mind must view facts in a very different light from my own.

The section below was taken at the same place as the two preceding sketches. It shows an irregular vein or mass of granite protruding through layers of mica slate. The granite mass is only two or three feet wide, and the mica slate four feet. It is obvious that the upper portion of the slate has here been forced upwards by the granite, so as to stand nearly perpendicular: the general dip being about 45° west.


(7) Granite Veins in Mica Slate: Norwich.

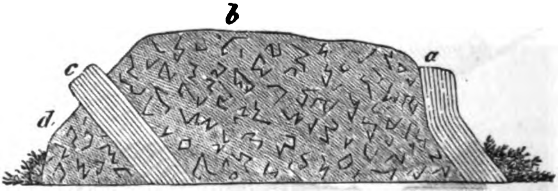
In the northwest part of Norwich I sketched No. 8. Two beds or veins of granite are here shown: the central one, or that between the strips of mica slate, from 6 to 10 feet wide, and the outer one, which is but partly exhibited, 4 or 5 rods wide. One object I have in view, is to show the curvature of the mica slate, where the central mass of granite expands. But the principal object is to show two sections across these rocks, four rods apart.



(8) Granite and Mica Slate: Norwich.

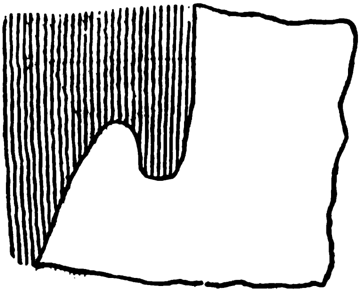
The change in the dip from 80° west, to 80° east, on the section from A to B, is striking; and is explicable alone on the supposition of a disturbing force exerted by these huge masses of granite.

The section below (No. 9) crosses from west to east, a ridge of mica slate and granite, about four rods wide. The stratum *a*, at its lower part, dips easterly about 25° or 30°; which is the usual dip of the slate in the vicinity; but the upper part of this stratum is thrown up nearly perpendicular; resting against the granite. This granite, *b*, is 3 or 4 rods across; when we find another stratum of the slate, *c*, having an easterly dip of nearly 50°. Below this another mass of granite, *d*, appears; but it is soon hid by the soil. Locality, near the line between Conway and Williamsburg.



(9) Granite and Mica Slate: Conway.

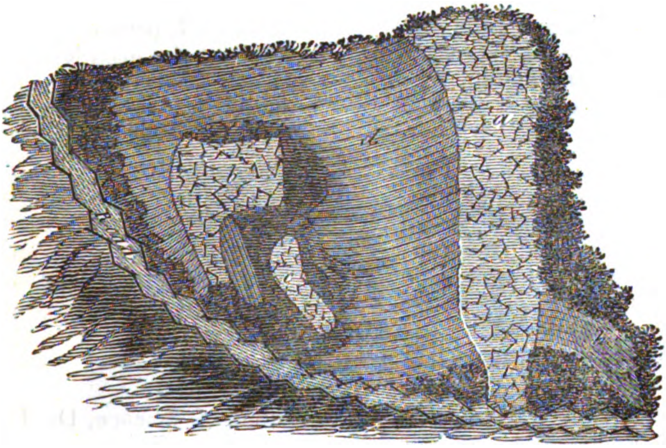
No. 10 is in the town of Russell, on the road from Westfield to Blanford. It represents a perpendicular ledge about 20 feet square, where mica slate and granite come in contact. The layers of the slate are perpendicular, and this rock is chemically united to the granite. It is easy to conceive how the two rocks should be thus weged into each other, if we admit that the granite was erupted while in a melted state: but I am unable to imagine any combination or peculiarity of circumstances, by which such a case can be explained on the theory of the aqueous origin of granite.



(10) Junction of Granite and Mica Slate: Russell.

The next case I regard as one of peculiar interest; chiefly, however, on account of its locality. It is not in Massachusetts:

but in Ackworth, N. H. at a remarkable locality of beryls, rose quartz, and crystalized mica. As the traveller approaches this spot, he will observe, while yet several miles distant, a remarkable conical, half-naked peak, chiefly of white granite, shooting up about 300 feet above the surrounding country. This is the hill represented in the sketch below, as seen on its northwestern side; along which a road passes. The prevailing rock in the vicinity is gneiss; but in this elevation it is chiefly hornblende slate, traversed by an enormous granite vein *a*, and exhibiting at least two protruding masses, *b*, and *c*, of granite. The vein varies from one half rod to four rods in thickness, and the mass *b*, is four or five rods across: *c*, is only 10 feet wide. The general direction of the laminæ of the slate is north and south, and the dip from 15 to 20° east: but we have here the most decisive marks of its having been irregularly upheaved and disturbed by the protruding granite. Near the foot of the hill the slate is bent upwards so that the chord of the curve is several rods long. But it is a curious fact that the axis of the elevating force seems not to have coincided with the direction in which the vein was erupted. For the highest point of the curve of elevation, near the foot of the hill, is to the right of the vein at *h*; and as we ascend the hill, we find the slate curved upwards near the vein more and more, as is shown in the drawing. Indeed, the granite of the vein seems to lie on the elevated edges of the slate; so that the lower side of the vein dips southeasterly; and does not cut the slate perpendicularly. These facts would seem to evince, that the vein made its way through the slate, not along the line of greatest pressure but

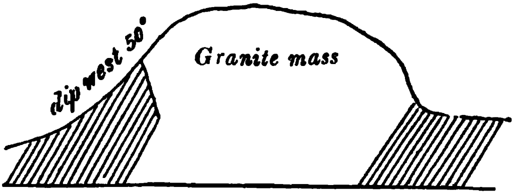


(11) Veins and masses of Granite in Hornblende Slate: Ackworth, N. H.

on the north side of it; probably because the slate there yielded most readily. We may suppose the melted granite below, to have gradually elevated the slate, until at length it burst its way laterally through that rock. Such cases, I believe, do sometimes occur in existing volcanoes.

The masses of granite, *b* and *c*, are probably other examples in which the same molten matter burst its way laterally through the slate. And it is an interesting fact in regard to the mass *b*, that in some places it still projects over the slate several feet, forming in fact an overlying mass. Instances of this kind I have rarely met with in the granite of New England. I recollect but one case precisely resembling this; and that is in the town of Carlisle, about two miles west of the meeting house, near an unfrequented road; where the granite has spread over mica slate several feet. But the sketch of that spot I have unfortunately lost.

The following sketch, however, which I took several years ago, appears to have a resemblance to those just described; especially to that of the vein *a*, in Ackworth, although I did not then examine the case as carefully as I should now. It occurs two miles north of Chester village in Chester. The granite mass is several rods wide, and the dip of the mica slate on each side of it, about 50 degrees west.



(12) Granite in Mica Slate: Chester.

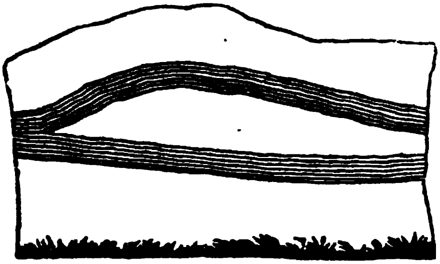
In the 8th Vol. of the American Journal of Science, Dr. Emmons has described an interesting case of overlying granite in Chester, with veins proceeding from it downwards. The mass is 5 rods in length.

A portion of the hornblende slate on No. 11 is seen running nearly east and west, or at right angles to the usual direction. Below the granite mass *b*, also, the strata are shifted almost 90°.

It is near the apex of this hill, that the interesting minerals above mentioned occur, and on the side of the cone opposite to that represented. The granite here is the coarsest I have ever seen: and probably the largest berryls in the world are found in it.

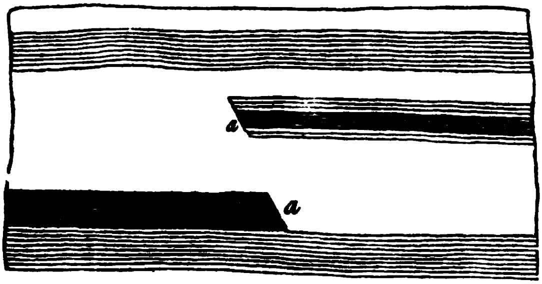
No. 13 exhibits the manner in which mica slate is sometimes enveloped by granite; the latter rock decidedly predominating. The spot here represented is several rods long, and occurs in

Chesterfield, a little north of the meeting house. The dip and direction of the mica slate do not differ much from what is usual in the vicinity.



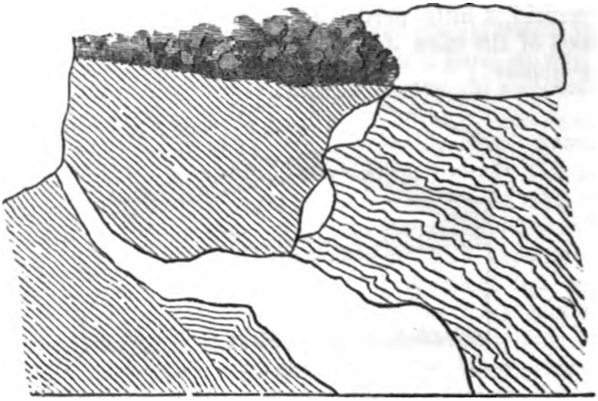
(13) Granite and Mica Slate: Chesterfield.

The following case, No. 14, occurs about half a mile east of the meeting house in Williamsburgh. A granite vein about four feet wide, runs here in the direction of the strata of mica slate. The dark stratum, *a a*, is hornblende slate, or perhaps amphibolic mica slate: and it appears to have been cut off and separated laterally a few feet. The upper mass of hornblende and mica slate is insulated in the granite, the narrowest vein of granite, however, being only three inches wide.



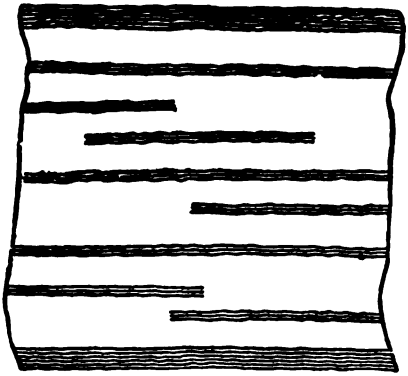
(14) Granite Vein in Mica and Hornblende Slate: Williamsburgh.

No. 15 represents two irregular masses of granite connected by a vein, or rather by two tubercular masses of the same rock. They occur in hornblende slate, two miles northeast of West Granville meeting house, on the road to Blanford. The strata of this slate usually stand perpendicular. Where thus penetrated by granite, however, the dip varies from 70° to 90° west; and its layers are exceedingly contorted. Their usual direction, also, is very much altered in some parts of the sketch. The sketch embraces a space of several square rods.



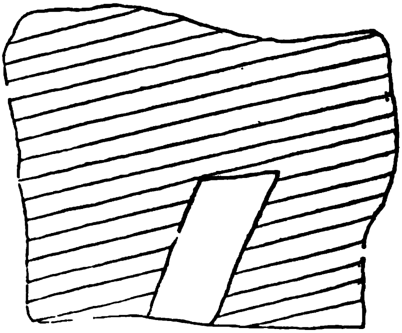
(15) Granite in Hornblende Slate: Granville.

No. 16 exhibits a mass of granite three rods wide, with mica slate on each side, and embracing strips of mica slate from one half inch to six or eight inches wide. The direction of the layers in these insulated strips corresponds with that of the mica slate generally in the vicinity: viz. a north and south direction. This case occurs in Chesterfield, one mile east of the meeting house, on the road to Northampton. It is easy to explain it on the supposition that the granite was erupted from beneath in a melted state: but I find it hard to conceive how such effects could have resulted from aqueous agency.



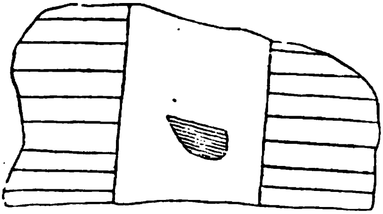
(16) Mica Slate in Granite: Chesterfield.

The sketch following represents a nearly perpendicular ledge of gneiss, from 70 to 100 feet high, in the lower part of which a mass of granite appears, which does not rise through the strata. The gneiss has a small dip to the west, though somewhat irregular. The vein of granite is from 10 to 12 feet thick, and rises thirty feet. The locality is on the north side of Housatonic river, near Southbury, Ct., close by what is called Zoar Bridge.

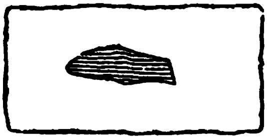


(17) Granite Vein in Gneiss: Zoar Bridge, Ct.

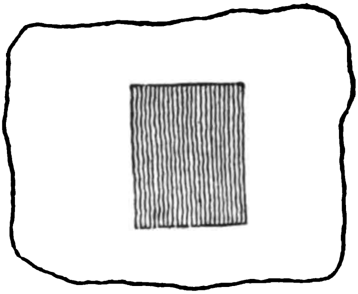
Nos. 18, 19 and 20 are representations of insulated masses of mica slate and gneiss in large veins of granite. The vein in No. 18, which is in the north part of Shutesbury, is ten feet wide, and the insulated mass of gneiss is almost three feet across in its longest direction. In No. 19, which is in Conway, the vein is fifteen inches wide, and the mass of mica slate (which is the rock traversed by the vein,) is thirty inches long. In No. 20, the imbedded mass of mica slate is eight feet wide and ten feet high; the layers standing perpendicular, and coinciding with those of the mica slate generally in that place. In all the cases described, it seems impossible to doubt but the schistose rock is perfectly insulated in the granite; and if so, does it not point to an igneous origin for the granite?



(18) Mass of Gneiss in Granite: Shutesbury.

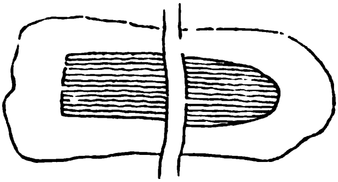


(19) Mica Slate in Granite: Conway.



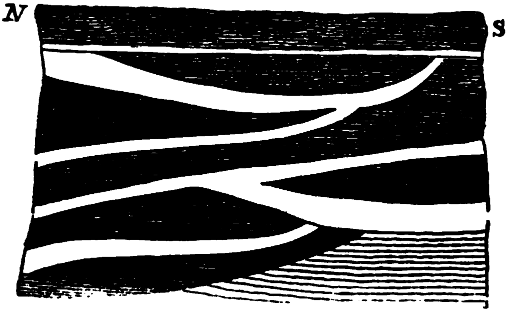
(20) Mica Slate in Granite: Chester.

No. 21 differs but little from the preceding cases. Two granite masses appear to be connected by two veins: the widest of which is two feet, and the other only six inches thick. Thus a piece of mica slate is insulated, and both this and the granite are cut by a more recent vein of granite, fifteen inches wide. This case occurs three miles northeast of the meeting house in Williamsburgh. But I have not personally examined it, and am indebted to Mr. Alanson Nash for the sketch.



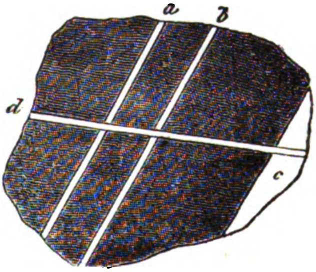
(21) Granite and Mica Slate: Williamsburgh.

Veins of granite traversing granite are more frequent in Massachusetts than in any other rock. Generally the veins are composed of much coarser materials than the rock that contains them: and by this mark alone can they be distinguished, except that sometimes the color of the materials of the vein and that of the containing rock, are different. The following case occurs in the west part of Whately, and exhibits a mass of granite of fine texture, about fifteen feet long and ten feet wide, with mica slate on one side. The dark part of the drawing represents this granite, and the white strips crossing it are veins of coarse granite. Must we not suppose such veins produced by the injection of granitic materials through a mass of granite while yet in a plastic state?

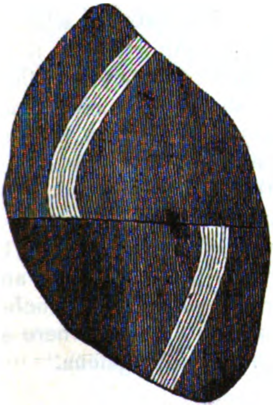


(22) Granite Veins in Granite: Whatley.

In No. 23 a coarse vein, made up almost entirely of feldspar, 20 inches wide, traverses a rather coarse granite. This vein has been cut off by a fissure crossing it nearly at right angles, and the two parts are separated seven feet. This lateral movement must have taken place after the consolidation of the rock. The case occurs in the extreme southeast part of Newport, R. Island.



(24) Granite Veins in Granite: Gay Head.

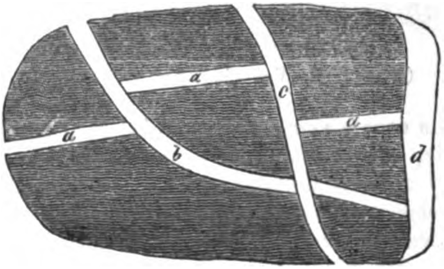


(23) Granite Vein in Granite: Newport, R. I.

No. 24 represents an enormous bowlder of granite, from 20 to 30 feet diameter, lying at the foot of the clay cliff at Gay Head, Martha's Vineyard. *a, b, c,* Are granite veins of the same epoch; as is proved by their parallelism. These are all cut off by a vein *d,* of subsequent date, crossing them nearly at right angles. Here then we have granite of three distinct epochs.

No. 25 shows us granite of four successive epochs of eruption.

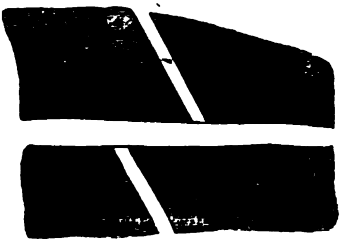
It is the sketch of a bowlder, 20 feet long and 10 feet thick, lying in Westhampton. The great mass of the rock belongs to the first epoch. The vein, *a*, *a*, *a*, was produced at the second epoch. This was intersected by *b*, at a third or subsequent epoch. This, as well as *a*, were intersected by the vein *c*, (and probably at the same time by *d*,) at a fourth epoch. The lateral removal of the middle portion of the vein *a*, seems to have resulted from the intrusion of the veins *b*, and *c*, whereby the wedged shaped portion of the rock between them was crowded out of its place.



(25) Granite Veins in Granite: Westhampton.

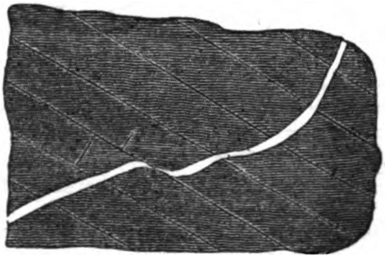
I have heretofore described and sketched a case in which a rock of sienite (sienitic granite,) contains granite veins of three successive epochs. The case now described corresponds to that, except that the base of the one sketched above, is genuine granite. Both of them, however, may be regarded as presenting us with a granite erupted at four successive epochs: and this is the greatest number that I have ever met with.

The next case is one of no peculiar interest, hardly worth preserving indeed. The sketch shows a vein of coarse granite, 10 inches wide, traversing a mass of finer granite, and cutting off and removing laterally another vein of coarse granite, 2 1-2 inches wide. It occurs in Southampton, not far from the spot where an adit has been made in the granite to reach a vein of galena.



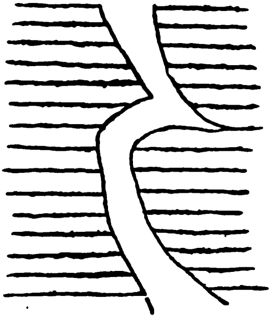
(26) Granite Veins in Granite: Southampton.

No. 27 shows a granite vein a little more than a foot in width, crossing strata of gneiss obliquely. After this vein was injected, the strata of gneiss seem to have slidden down so as to cut off the vein in at least two places, and near those spots the vein is considerably reduced in size, as if in a plastic state when the disturbance took place in the gneiss.



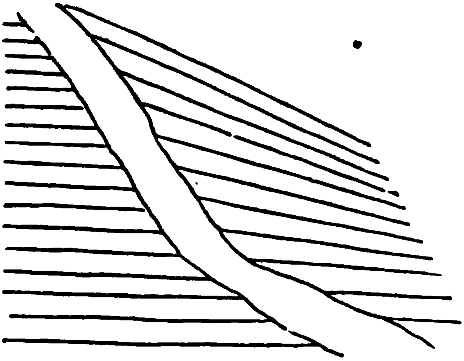
(27) Granite Vein in Gneiss: Shutesbury.

The five next cases, viz. 28, 29, 30, 31, and 32, were sketched in New Bedford and Fairhaven: all but Nos. 29, and 31 on Palmer's Island, in New Bedford Harbor. They all occur in gneiss. No. 28 is interesting chiefly on account of the peculiar form of the vein, which varies in width from two feet down to six inches. It exhibits the vein as it appears on the basset edges of the gneiss where the strata dip to the north about 35°.



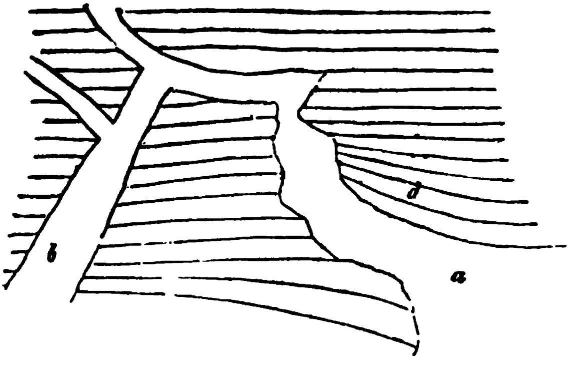
(28) Granite Vein in Gneiss: Palmer's Island, New Bedford Harbor.

The surface sketched in No. 29 is nearly horizontal; and the strata of gneiss dip as in the last case. On one side the direction of the strata is changed, apparently through the influence of the vein, as much as 10° or 15°. The vein is 15 inches wide.



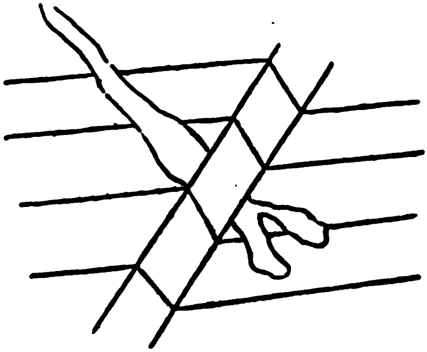
(29) Granite Vein in Gneiss: at the fort in Fairhaven.

No. 30 exhibits also the basset edges of the gneiss strata where they dip 35° northerly. A mass of granite, *a*, which is several feet wide where it first appears above the soil, sends off a very crooked vein of six or eight inches wide, which connects with another vein, *b*; which last vein also sends off a narrow branch. At *d*, the edges of the strata are curved considerably, obviously in consequence of the granite in their vicinity.



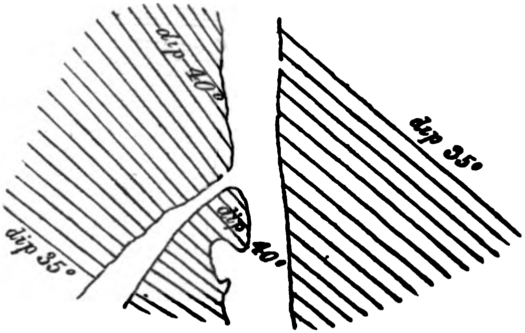
(30) Granite Veins in Gneiss: Palmer's Island, New Bedford Habor.

In No. 31 a vein of granite about six inches wide, is intersected by another a foot wide. The strata of gneiss on one side of the last mentioned vein have also been moved laterally about four inches; so that the seams do not correspond on opposite sides. I am inclined to believe that it is an error in the sketch, that it does not show a similar slide in the vein that has been intersected: though I have no recollection on the subject. The basset edges of the strata are here represented.



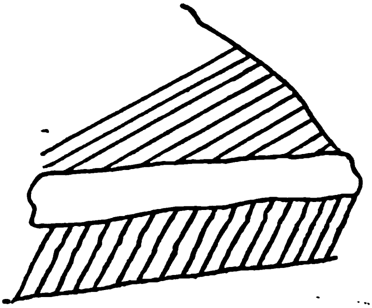
(31) Granite Veins in Gneiss: Fairhaven.

No. 32 is a nearly perpendicular section, running nearly north and south across the strata of gneiss, and showing an irregular branching vein. The principal vein is two feet wide, the branch about one foot. It will be seen that the general dip of the strata is 35°; and that this is increased to 40° on the lower side of the vein. This is one of those cases which would be appealed to in proof that veins were filled from above. The disturbance of the strata, however, proves that it was not filled by crystalization from aqueous solution. The lower edge of the section corresponds to high water mark. The spot can well be examined only in a boat.



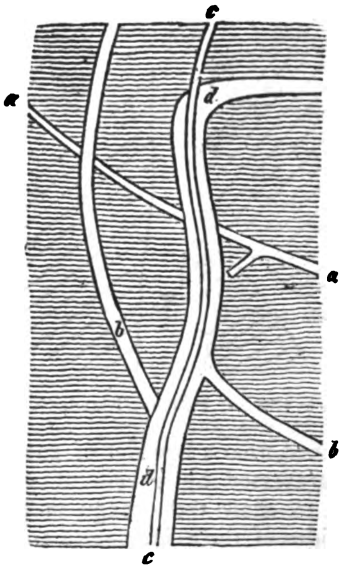
(32) Granite Vein in Gneiss: Palmer's Island, New Bedford Harbor.

No. 33 was sketched from a bowlder of gneiss in the south part of Tolland. It is traversed by a vein of granite a foot wide. The only object is to show the change in the direction of the strata on different sides of the vein.



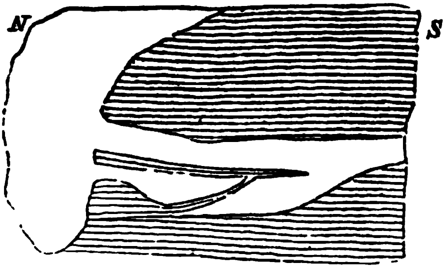
(33) Granite Vein in Gneiss: Tolland.

For No. 34, taken in the northeast part of Williamsburg, I am indebted to Mr. Alanson Nash. *a, a,* Appears to be the oldest vein of granite in mica slate; and is only two inches wide: *b, b,* is a second vein; as is proved by its cutting through *a, a,* and is of the same width as *a, a,*: *d, d,* is a third vein; as is proved by its intersecting the two first. It is six inches wide: *c, c,* is a fourth vein, two inches wide, intersecting *d, d,* longitudinally, and distinguished from that by being of a much coarser texture. This is a very unusual occurrence: one which I have myself never seen; and we have here also granite of four epochs; so that this example, if there be no mistake in its representation, is a very interesting one.



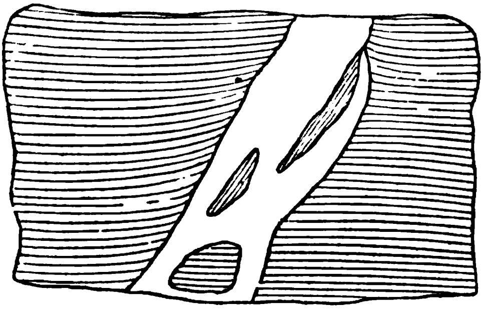
(34) Granite Veins in Mica Slate: Williamsburg.

In No. 35 a large protruding mass of granite rises from the soil at the north end of a naked ledge of mica slate, which is two rods wide, as represented on the sketch. From this mass of granite an irregular vein proceeds nearly in the direction of the layers of slate, embracing two or three nearly insulated strips of mica slate. I am not aware that any very instructive inference can be derived from this case, except that it seems to me impossible to impute to deposition from water, a mass of granite thus irregularly intruded among the mica slate. It occurs in the west part of Whately.



(35) Granite Veins in Mica Slate: Whately.

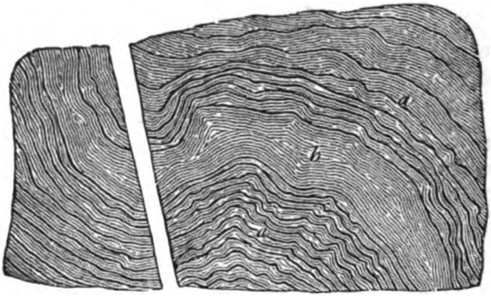
No. 36 is situated near the same spot. It represents the inclined surface of a ledge of mica slate, through which a granite vein of four feet wide passes. This embraces three masses of mica slate of considerable size, which are evidently separated entirely from the parent rock, except one of them nearest the upper side of the sketch. The layers of the mica slate, in the direction in which the granite was erupted, are obviously considerably curved, as is shown in the figure.



(36) Granite Vein in Mica Slate: Whately.

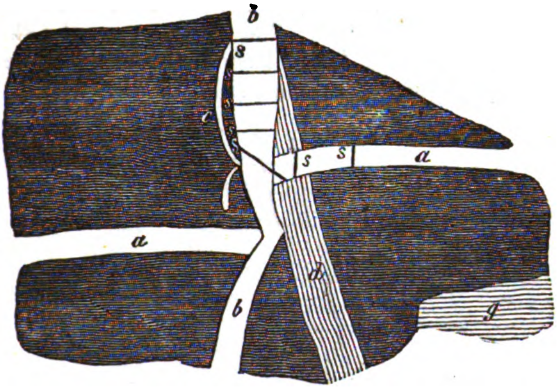
No. 37 represents a nearly perpendicular ledge of mica slate in Conway, very much contorted, about two miles southwest of the centre of the town. *a, a,* Are strata of common mica slate:

b, is a stratum of amphibolic mica slate. The whole surface exhibited is fifteen feet long and eight feet high. Through this ledge runs a vein of fine grained granite a foot wide. The object of giving the sketch is to show that this vein has produced no derangement of the mica slate: for the different varieties of that rock occupy the same relative position on the different sides of the vein. Hence the vein was introduced subsequently to the consolidation of the slate; and probably it was injected into an open fissure. Hence, too, we must be cautious in imputing contortions in mica slate, even in the vicinity of granite veins, to their eruptive force.



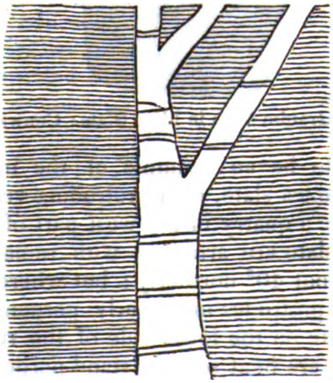
(37) Granite Vein in Mica Slate: Conway.

No. 38 was sketched only 100 rods northeast of the congregational meeting house in Conway. It represents two granite and several quartz veins, in coarse micaceous limestone. *a, a,* Appears to have been the oldest granite vein, and is a foot wide on the right hand side of *b, b,* and twenty inches at the other extremity. 'This is intersected by another granite vein, *b, b,* and the two extremities are removed asunder forty-two inches. *c* Is a curved branch of this vein: *b, b,* is from twelve to eighteen inches wide. *s, s, s, s, s, s, s,* Are quartz veins, from half an inch to two inches wide, and one of them it will be seen, intersects both the granite veins; and, therefore, these quartz veins appear to have been of posterior origin to both the granite veins. *d* and *g,* Are masses of mica slate, with which rock the micaceous limestone, (that constitutes the dark part in the sketch,) is interlaminated in the vicinity. The direction of the layers of slate in the mass *g,* corresponds with that of this rock generally in the vicinity: but in what manner the mass *d,* should have been thrown at right angles to this direction, it seems difficult to imagine. It is obvious, however, that these granite veins have produced great disturbance in this spot.



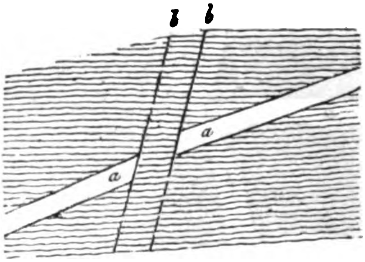
(38) Granite Veins in Micaceous Limestone: Conway.

In the same town and near the same spot, may be seen the original of No. 39. We have here a vein of granite, 40 inches wide, which sends off two branches; the first at an angle of 20° and the second at an angle of 50°. Both the branches are 18 inches wide, and the portion of the vein which continues in a direct course is 14 inches wide. Intersecting these veins of granite, we find several of quartz, whose width varies from one inch to three inches; and whose direction corresponds with that of the continuous layers of mica slate. The probability is that these, like most other quartz veins, were the result of the infiltration of siliceous matter into fissures previously produced by desiccation or mechanical force.



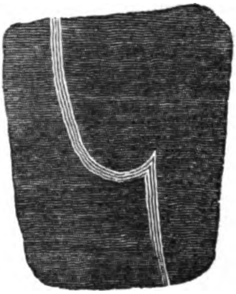
(39) Granite and Quartz Veins in Mica Slate: Conway.

No. 40 is in the same town. *a, a* Is a granite vein approximating in direction to the layers of mica slate; the two parts of which are separated by mica slate several feet, and one extremity is not as wide as the other. The two parts are also shifted laterally by the two fissures, *b*, *b*. I confess myself unable to give any satisfactory solution of the anomalies of this case.



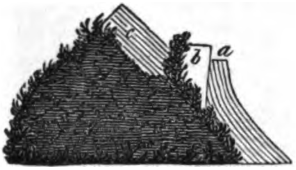
(40) Granite Vein in Mica Slate: Conway.

No. 41 was sketched from a bowlder in Conway, merely on account of the peculiar form of the granite vein which traverses mica slate. The widest part of the vein is only an inch across, and this is reduced to half an inch at the other extremity. I neglected to sketch the direction in which the layers of slate run.



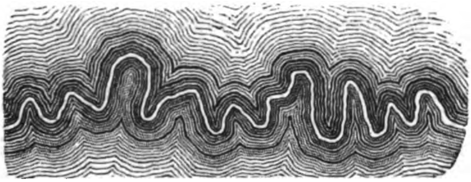
(41) Granite Vein in Mica Slate: Conway.

No. 42 appears to be an example of the mechanical effects upon the layers of mica slate, of a protruding vein of granite. It occurs at Narrymore's quarry in the west part of Goshen; where the layers of mica slate are arranged with remarkable regularity. The dip there is about 40° northerly: but where a granite vein of four feet wide, (*b*,) protrudes in a nearly perpendicular direction, the strata of the slate on the lower side of the vein, for the width of eight inches, (*a*,) are bent so as to stand perpendicularly against the vein. On the upper side of the vein, and immediately in contact with it, the slate is hidden by soil: but it appears again a few feet distant at *c*. This example was brought to light by the quarrymen, and as it was sketched several years ago, ere this they may have destroyed all traces of it.



(42) Granite Vein in Mica Slate: Goshen.

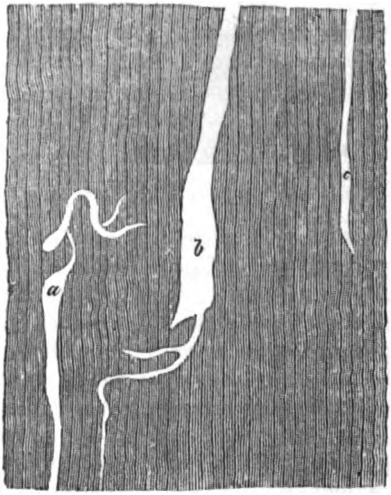
No. 43 represents a vein of granite, only one eighth of an inch thick, traversing mica slate in Conway, one mile southwest of the congregational meeting house. Strictly speaking it is a bed; for it is interlaminated with the slate and conforms to its tortuosities. It is not perhaps easy to conceive how such a vein could have been intruded between the layers of the slate, on account of its extreme thinness. Perhaps it ought rather to be regarded as one of the layers of the slate, produced in the same manner as the laminæ of gneiss.



(43) Granite Vein in Mica Slate: Conway.

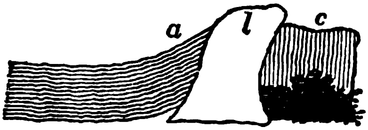
No. 44 was sketched near the same spot. It represents the edge of a thick stratum of mica slate, whose dip is 50° east: and whose laminæ correspond in the dip to the strata seams. Among these laminæ and running in nearly the same direction, are three narrow and quite irregular granite veins. *a* Seems to have been injected from below, and has no apparent connection with *b*, which would seem to have flowed in from above. *c* Is a third very narrow vein only one fourth of an inch wide, which has no connection with the others.

I have sketched this case, because it seems more favorable than any I have met with, to the old Wernerian notion of the filling up of veins by infiltration from water. Yet there is nothing in the case inconsistent with the igneous origin of the granite; for if that rock was originally in a molten state, it would flow horizontally and downwards through any openings that were made for it: and we have only to suppose that *b* and *c* have an unseen connection with a mass of granite that has been forced upward. And that such a mass exists in the vicinity, the vein *a*, having no opening above, shows to be probable. Such masses also appear at the surface in the vicinity.



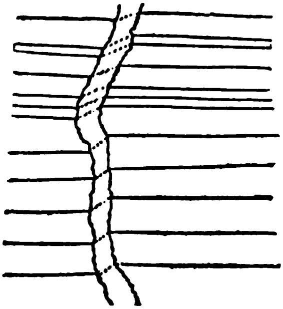
(44) Granite Veins in Mica Slate: Conway.

No. 45 occurs in Goshen, not more than a mile or two from No. 42; and it is analogous to No. 42. It may be seen two miles west of the village, on the old road to Cummington, on the margin of a pond. It represents a ledge of mica slate a few feet high, whose strata dip from the observer, and whose basset edges only appear. On coming within 30 inches of the mass of granite *b*, the laminæ of slate are bent upwards 20°; and on the other side of the granite, *c*, they actually stand perpendicular or even lean a few degress from the granite. The width of the protruding mass of granite, which is partly hid by the soil, is from three to four feet. It is common to see mica slate and other stratified rocks as much disturbed in the vicinity of granite as this case exhibits: but it is not common to meet with the disturbance on so small a scale.



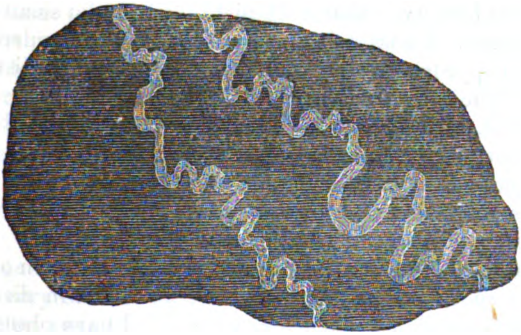
(45) Granite Vein in Mica Slate: Goshen.

The mica slate in the northwest part of Norwich is frequently very regular in its stratification, dipping west 80°; and this is the case where No. 46 was sketched. A granite vein four inches wide crosses the strata nearly at right angles, and the edges of the mica slate show that the layers on opposite sides of the vein have been moved a few inches laterally. The distinctness of the stratification enables us to see this change more easily than is common.

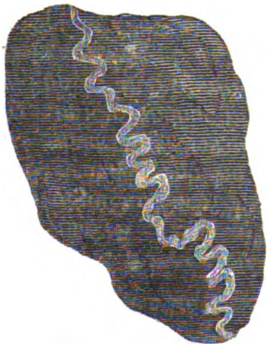


(46) Granite Vein in Mica Slate: Norwich.

Nos. 47 and 48 represent granite veins in micaceous limestone in the west part of Colrain. They are bowlders of about two feet in diameter, and the veins only an inch or two wide. The extremely serpentine course of these veins is the most remarkable



(47) Granite Veins in Micaceous Limestone: Colrain.



(48) Granite Vein in Micaceous Limestone: Colrain.

circumstance about them. For I could not discover any cause that makes them thus serpentize. The limestone appears perfectly homogeneous throughout, and is entirely destitute of any appearance of a laminar, slaty, or stratified structure; I mean so far as these specimens are concerned.

I shall not in this place deduce any general theoretical inferences from the facts respecting granite veins that have now been detailed. In the sequel, however, I may refer to them again, so far as they have a bearing upon theory.

Mineral Contents.

In every part of the world granite is the repository of very many of the most perfectly crystalized minerals: an evidence that its materials must once have been most thoroughly fluid, either by water or heat. The number of mineral species in the granite of Massachusetts is not quite as numerous as in one or two other rocks: yet it contains several of the most interesting minerals in the State.

Sulphate of baryta is extremely abundant in it; though the most prolific locality,—that in Hatfield,—occurs in sienite, and has been described. A considerable part of the matrix of galena, blende, and copper pyrites, at the Southampton mine, consists of this mineral. The most southerly vein of lead ore in Leverett, also, abounds in it, as the gangue of the galena. And both the metallic veins in that place are in granite. The baryta occurs generally in foliated masses: sometimes in tabular crystals. The folia are sometimes curved; and sometimes, as in Leverett, the specimens are coarsely granular. The color is uniformly white.

Carbonate of lime is rare in granite: but in the vein of metallic ores above spoken of at Southamption, we find it in distinct crystals; sometimes of a delicate straw color. I have observed there a dodecaedeon composed of two six sided pyramids: a short six sided prism acuminated by three faces: also the same with all the solid angles of the prism truncated, producing a trapezoedron. This mineral more frequently is laminated.

The situation of the argentine in Westhampton, partly in the mica slate and partly in the granite, renders it proper to speak of it as belonging to either rock: but under micaceous limestone I have given a full description of its geological position; and its mineralogical characters correspond so well with those that are given in the books, that nothing more need be added. The locality cannot for a considerable time, if ever, be exhausted; unless it should be visited by some of those insatiable collectors, who carry away specimens by the ton. (Nos. 1490, 1491.)

This same mineral has been found at the Southampton lead mine.

At the most northerly vein of galena and pyritous copper in Leverett, I have found a few specimens of crystalized brown spar.

In Billerica and Stow, phosphate of lime has been found by Professor Webster in very coarse granite: also by Dr. C. T. Jackson, in the same rock in Lancaster, in connection with spodumene.

At the Southampton lead mine, green and purple fluate of lime has been found, but not in large quantities: though should this mine ever be wrought extensively, there can be little doubt that abundance of it will be brought to light.

At the same place we meet with crystalized limpid quartz in great abundance. Sometimes the crystals are penetrated throughout by a yellow coloring matter, so as to form genuine yellow quartz. Radiated quartz forms the greater part of the gangue of the lead and copper ores, in the several veins of these metals that have been described as existing in Hampshire county, in the first part of this Report. In Chester, the quartz in this rock is sometimes rose red. In Goshen its crystals are sometimes of an extremely delicate smoke color; and in Williamsburgh, this variety occurs uncrystalized in large quantity, about two miles west of the meeting house. In Bristol, Rhode Island, occur fine specimens of amethyst; which are said to proceed from the granite of Mount Hope. This locality a few years since promised something for the lapidary.

At the Southampton lead mine pseudomorphous quartz is sometimes met with. But the most interesting locality is in the galena vein near the argentine locality, in Westhampton. The pseudomorphous crystals are very perfect, and have the form of *hog tooth spar*, and of cubic fluate of lime. These crystals are hollow, and generally very drusy without and within. It is now, however, very difficult to obtain specimens, especially of the variety that has assumed the form of fluor spar. (Nos. 1501, 1502.

In Conway I observed that some of the quartz in coarse granite was highly fetid. The same is found is Chester.

A mineral is sometimes seen at the Southampton lead mine, which appears to be hornstone. (No. 1502.)

Pinite, according to Dr. C. T. Jackson, has been found in granite on George Hill in Lancaster, and of fine quality.

In the 20th Vol. of the American Journal of Science, I have described a specimen of limpid topaz in granite, found upon the White Hills in New Hampshire. In Haddam, Ct., it is well known, occurs the chrysoberyl in the same rock.

Spodumene abounds in our granite. Goshen is its most abundant locality. About two miles north of the village, it occurs on the road to Ashfield; and also about three miles northeast of the centre of the town, on the road to Plainfield, at a locality long celebrated for furnishing several interesting minerals. It is found likewise in Chesterfield, Norwich, and Chester. In all these places its characters are similar. It occurs in prismatic masses whose crystalline form cannot be determined. These masses are sometimes four or five inches across, and sometimes of great length. Dr. Dwight of Cummington showed me a specimen from Chesterfield, containing a prism 21 inches long, yet broken off at both ends. These larger masses are commonly of a white or gray color, and resemble feldspar. But the smaller specimens are frequently of a delicate green color, resembling very much the spodumene from the north part of Europe. A few specimens I have noticed of a light rose color. (Nos. 1504 to 1507.)

This mineral occurs also in Sterling, in a granite rock. This spodumene has more of a pearly aspect than that in the western part of the State; as the specimens in the collection will show. It is also of a more milky white color. (No. 1508.)

Dr. Emmons is of opinion that 'the large cleavable variety' of lepidolite occurs in Goshen. Probably he refers to the mineral that has been generally regarded as rose mica.

The varieties of mica in our granite are numerous and interesting. The rose red, just referred to, has been found only I believe in the northwest part of Goshen, where it sometimes occurs in oblique rhombic prisms; which is its primary form. In the same place, also, and likewise in the northwest part of Chesterfield, at the tourmaline locality, a delicate yellow mica of various shades is found under the same form; and still more frequently, a transparent or silver colored variety. But the most remarkable locality of crystalized mica is in Ackworth, N. H.; where are found finer specimens, associated with beryls and rose quartz, than at any other spot in this country. The crystals are distinct six sided tables, disseminated through gray quartz, and attached to fine grained feldspar. They vary in size from half an inch in diameter to an inch and a half. I have some reason to fear, however, that this locality may not prove very prolific.

Prismatic mica is found in Goshen, Chesterfield, Norwich, and Leverett. But the specimens which I have found in Russell are the best. (Nos. 1512 to 1514.) The general color of the prisms is light smoke gray; but we sometimes see in them distinct strips, penetrating deep into the specimen, of a very dark bronze color; appearing black, indeed, except in very thin plates.

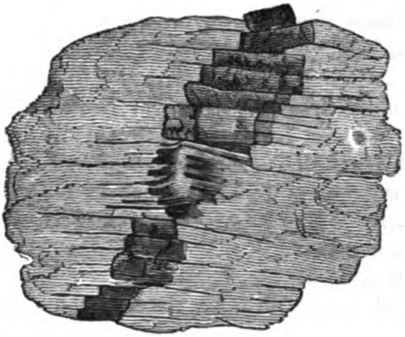
Plumose mica (*Mica fibreux*, Beudant,) is quite common in Williamsburg, in several places west and northwest of the village. The name is derived from the resemblance between the arrangement of its lamellæ and those of a feather; which indeed is often quite striking.

The granite of Massachusetts contains almost every variety of the schorl family that has been found on the globe. Common black schorl is most abundant. In Chesterfield and Goshen its crystals are sometimes large, but generally quite imperfect. In Norwich its crystals are terminated by pyramids. In Westford, also, I met with it in small very short acuminated crystals. (No. 1547.)

Of the tourmalines we have every variety, except perhaps the yellow and the white. Indicolite occurs at the greatest number of localities. In Chester it is found in large crystals; also in connection with the the green and red varieties in the northwest part of Goshen, associated with several other minerals.

The most noted locality of green and red tourmalines is in Chesterfield, on land of Mr. Clark. They are contained in an enormous vein of granite in mica slate, which corresponds nearly in direction with the layers of the slate. This granite is crossed obliquely by a vein, varying in width from six to eighteen inches, of smoky quartz and silicious feldspar: or rather, the quartz forms the central part of the vein, and the feldspar lies on each side of the quartz: the green, red and blue tourmalines, with schorl and sometimes beryl, passing through the feldspar and the quartz. This cross vein has been laid open from twelve to twenty feet by blasting; and it is really, in the eye of a mineralogist, a splendid object. I do not see that there is any prospect that it will soon be exhausted; although I doubt whether as fine specimens are now obtained from it as formerly.

The crystals of green tourmalite and rubellite at this locality occur in rounded prisms, deeply striated longitudinally. They have been found an inch in diameter, but generally they are much less, and the red are rarely more than one quarter of an inch: sometimes they exhibit triedral summits. It is very common for the rubellite to be enclosed in the green crystals, and sometimes a thin layer of talc intervenes between the inner and the outer crystals. Col. Gibbs found three of the red crystals in one instance aggregated together, and enclosed by one of green. The green crystals also sometimes embrace indicolite, and sometimes indicolite encloses the green tourmaline, as may be seen by the specimens Nos. 1521, 1522 and 1524. The green tourmalines, as well as the rubellite, are sometimes entirely distinct from each other; especially when they are contained in the quartz. In some instances I have met with marks of rather singular disturbances which took place while the green tourmaline was crystalizing in the quartz. The quartz is fissured into somewhat parallel laminæ, and together with portions of the crystal has been subjected to a sort of *echellon* movement, while in some places it has been so compressed as almost to disappear. This last circumstance seems to indicate that the disturbance took place before the crystalization was completed. The following sketch is intended to represent this phenomenon.



Crystal of Green Tourmaline in Quartz: Chesterfield.

The colors of the tourmalines in Chesterfield are pretty uniform: but in Goshen they vary exceedingly. The rubellite is rarely met with there; but the indicolite is abundant; and this passes by numerous gradations into green tourmalines. Of some specimens, indeed, it is difficult to say whether they should be regarded as blue or green. There also we meet with a yellowish green tourmaline, (No. 1520,) which is associated with spodumene. Sometimes also I have seen this mineral nearly brown and even approaching to white. At Chesterfield the green variety is opaque: but some of its crystals at Goshen, penetrating mica, are translucent.

All the common varieties of feldspar are of course abundant in our granite. Its ordinary color is white. But in Leverett it is blue; and often the folia are six or eight inches across. In Goshen I have met with it slightly green. The siliceous feldspar, or Cleavelandite, is found as already noticed, at Chesterfield, where it is commonly foliated, but sometimes coarsely granular. At Goshen the same varieties occur: and that which is granular exceedingly resembles saccharine limestone. In Norwich it is found foliated and of a light blue color. At the other localities it is always white. Mr. Andrews, preceptor of New Salem Academy, finds it in foliated masses in that town of that color. It is found also at Chester. (Nos. 1535 to 1539.)

Beryls are frequently met with in our granite: though in general they are not very delicate. Perhaps the most so is a limpid beryl, occurring in Goshen along with spodumene, &c. It is rarely distinctly crystalized and is full of fissures. Sometimes it is of a light rose color. (Nos. 1525 to 1528.) In Norwich and Chesterfield beryls are sometimes found of a great size;—at the latter place a foot in diameter; but such crystals are irregular and devoid of beauty. In Williamsburgh they sometimes occur smaller, but more valuable. From Pelham I have a specimen of greenish yellow beryl, of considerable beauty; beryls are said also to have been found in Worthington: and Dr. Marshall showed me a fine crystal 1 1-2 inch diameter, found in the granite of Fitchburg. In Stow, also, this mineral has been found in granite.

It has been stated that iolite is found in the granite of Goshen: but I have never met with it. In the granite of Haddam, Ct. it has lately been found abundant and beautiful.

Garnet is less abundant in our granite than in several of the older stratified rocks. Generally where it does occur, it is in quite small crystals; but it is commonly the precious garnet. In Bedford it is said to be found in large and sometimes perfect trapezoidal crystals.

If No. 1529 do not belong to the zeolite family of minerals, I cannot tell where to refer it. I mean the radiated mineral upon fine granite from Goshen.

I believe that all the veins marked on the Geological Map, as well as on Plate XVII, as lead veins, in Hampshire county and the south part of Franklin, are either entirely contained in granite, or pass from that rock into mica slate. Hence the minerals which they contain may properly be described in this place.

The gangue of the most southerly vein in Leverett is sulphate of baryta and quartz. It is only a foot or two in width, and is entirely in granite. It contains galena only. The most northerly vein in that town is several feet wide, and is mostly in mica slate. It contains galena and pyritous copper in nearly equal proportion.

The vein in Southampton to which I have often referred, and which has been explored farther than any other in the State, traverses granite and mica slate; and the gangue is mostly quartz with sulphate of baryta occasionally. Its extent and situation have, however, been already given in the first part of my Report with sufficient minuteness. Galena is the principal ore. Blende, however, is frequent, as well as pyritous copper. Here also have been found the carbonate, molybdate, sulphate, phosphate, and murio-carbonate of lead; the blue and green carbonate of copper and vitreous black oxide of iron. Here also we find sulphate of iron in small octahedra, truncated on all their angles. The carbonate of lead is found in tabular prisms with bevelments: also in six sided prisms with four sided acuminations: also in triangular dodecaedra with their apices deeply truncated. The murio-carbonate of lead is in light green groups of cubic crystals terminated by tetraedral pyramids. The sulphate of lead occurs in small plates on the galena. The phosphate of lead exists in spherical light green masses.

The vein in the south part of Southampton is said to have a gangue of quartz containing galena, and to be not more than a foot wide. I have not visited it.

About a mile northeasterly from the adit in Southampton, a vein of quartz, mostly radiated, several feet wide, traverses mica slate chiefly, and contains blende and galena; the former in much the greatest quantity. The blende here, as well at all the veins in the vicinity, is foliated, rarely in distinct crystals, and of a honey yellow color.

The metallic vein in Westhampton, near the locality of argentine, is very large, at least 10 feet wide; though I could not ascertain its true width. It is composed entirely of radiated and crystalized quartz, surrounding small masses of some other rock, probably mica slate, the whole mass having a brecciated appearance. Galena, the only ore that has been found here, is very sparingly disseminated. I could not ascertain whether this vein is in granite or mica slate; both of which rocks occur in the vicinity.

The veins in Williamsburgh, according to Mr. Nash, occur in granite and mica slate, and the gangue is quartz. Only one of them, however, has been discovered in the rock, their existence being inferred from the loose blocks strewed over the surface. In at least one of these veins, the oxide of manganese occurs, along with galena. Pyritous copper exists there also, in small quantity: and I found foliated blende. This latter ore appears to have a strong tendency to decomposition, and often the cavity that contained it, is filled with a dull red powder, whose true nature I have not ascertained. But it is certainly not the oxide of lead, as Mr. Nash has stated in the 12th volume of the American Journal of Science!

The three veins in Whately have all a gangue of quartz, generally radiated. The most easterly one, according to Mr. Nash, contains oxide of manganese as well as galena. The most northerly one is six feet wide and lies chiefly in granite. It contains blende as well as galena. The two other veins described by Mr. Nash I have tried in vain to find.

According to the Messrs. Danas, muriate of copper has been found in rolled masses of granite in Woburn.

It is said, also, that specular oxide of iron occurs in Mendon, and in Cumberland, R. Island, in granite.

In the 16th volume of the American Journal of Science, I have given a very particular account of the single crystal of the oxide of tin, which I found several years ago, at the well known locality of several interesting minerals in the northwest part of Goshen. Its form, if I did not mistake it, was an octahedron with a square base: though the measurements of several of the angles did not coincide with those given in the books. But as to its being genuine oxide of tin, there can be no doubt: especially since the discovery in Europe of this same substance in a specimen sent from Chesterfield, Mass. as mentioned in Mohs Mineralogy.*

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* Vol. II. p. 387. Edinburgh, 1825.

Mr. Nuttall suggests with a doubt, that the phosphate of manganese exists in Sterling, in connection with spodumene. The same mineral, whatever it be, is found in Goshen with the spodumene.

Sulphuret of molybdenum has been found in granite in New Bedford and Fitchburg.

The only remaining mineral to be noticed in the granite of Massachusetts, is the columbite at Chesterfield. It was discovered at the tourmaline locality by Mr. C. U. Shepard, in right rectangular prisms with several modifications. The same gentleman found this rare mineral in two places in Goshen, imbedded in spodumene.

Theoretical Considerations.

I have already expressed the decided opinion, that if an igneous origin be assigned to the trap rocks, as is now done almost universally, a similar origin cannot be denied to granite. There is not indeed, so great a resemblance in appearance, between granite and recent lavas, as between these and the trap rocks: nor does granite occur in columnar masses. But except in these two respects, the same arguments which prove the igneous origin of the traps, equally apply, and sometimes I think with more force, in proof of the original igneous fluidity and protrusion of granite. And if I mistake not, there are one or two additional arguments in the case of granite. I shall now briefly present these arguments as they apply to the granite of Massachusetts.

1. *I infer the igneous origin of granite from the inclined position of the older stratified rocks.* The stratified and slaty structure of these rocks is conclusive evidence that water was the medium of their original deposition. But if deposited in water, their laminæ could not at first have varied much from a horizontal position: for we know of no examples in which depositions take place in water, where the surface is inclined more than a few degrees, except perhaps in those limited cases, where tufaceous masses are deposited from water charged with lime or silex, flowing down inclined planes. But the older stratified rocks are for the most part highly inclined, often vertical indeed, as the accompanying Sections will show. (Plates XVII and XVIII.) They must, therefore, have been elevated subsequently to their deposition. And when we find that a large proportion of the organic remains in the secondary rocks are of marine origin, can we doubt that existing continents once formed the bottom of the ocean? This opinion must now be regarded as an established principle in geology. But by what power was this elevation accomplished? That it was volcanic in the sense in which that term is now generally employed, I

very much doubt: because it seems to have acted along extended lines, and not from a centre or centres. An hypothesis as to its nature, I shall suggest in another place. But I cannot conceive how the stratified rocks could have been elevated as we find them, without admitting two conditions. First, that the solid crust of the globe must have been comparatively thin, in order to give way to any internal force that we can imagine might act upon it. Secondly, that a molten mass must have existed beneath this crust, so that when it was elevated in any particular part and depressed in others, the fluid nucleus might have readily conformed to the sinuosities of its inferior surface. Where, for instance, a long mountain ridge was lifted up, if no such fused matter were forced underneath it to occupy the cavity thus produced, it is difficult to conceive how it could be sustained through a lapse of centuries. Nay, it is difficult to conceive how such an enormous weight could have been lifted up thousands of feet, if such a molten mass had not been pressing against it beneath with considerable force, and thus lending assistance to any lateral agency that might have been in operation. Now if granite were not this fused plastic mass, we shall search in vain among the rocks to find one that could have been in such a state: for the trap rocks are not in sufficient quantity to answer the conditions of this case; and they are, moreover, usually associated with the newer stratified rocks. But granite corresponds both in its nature and position with such a supposition. And if we exclude the agency of granite, I do not believe we can account for the elevation of the strata which all admit has taken place.

2. *I infer the igneous origin of granite from the manner in which it is intruded among the stratified rocks.*

This argument is far more striking in the case of granite than in that of greenstone. For it is hardly possible to conceive of any anomaly of position which the former rock has not assumed in relation to the stratified ones. Its veins are of every size and shape, and they run in all directions through the superincumbent strata; and similar irregularities exist in its larger and less ramified masses. True, they are rarely superincumbent upon the stratified rocks; and hence some have inferred that they could not have been erupted like trap and lava, which often spread over the surface to a great extent. There is, however, one consideration—to waive all others—which it seems to me obviates this difficulty. We have abundant evidence that the surface of the earth has suffered a powerful abrasion in past ages; and since granite is confessedly older than the traps, it must have suffered most from this cause. Now who can tell but granite did once exist in overlying masses, and that those have been mostly worn away, and their remains entombed in the later rocks which so abound in nodules of granite? If existing causes operate long enough, the overlying masses of trap, now so common in various places, must be thus swept away, and its veins and protruding masses alone remain.

This argument, however, cannot be felt in all its force, without connecting it with another circumstance which forms my next argument.

3. *I infer the igneous origin of granite from the mechanical effects which it appears to have exerted upon the stratified rocks in its immediate vicinity.*

To illustrate these effects is a principal object which I had in view in giving so many sketches of veins and protruding masses of granite. Most of these cases seem to me totally inexplicable on any other supposition than that of the protrusion of the granite while in a fluid or semi-fluid state. But after all, such sketches convey only a very imperfect conception of the actual marks of disturbance, which the stratified rocks in the vicinity of granite exhibit. Their dip and direction are changed in every possible manner, and larger or smaller masses of the stratified rocks are partially or entirely separated from the parent rock, and more or less enveloped in the granite, which is united to them chemically. If any candid man will go into the towns of Williamsburgh, Whately, Conway, Chesterfield, Goshen, Westhampton, Norwich, Chester, Granville, or many others that might be named, and carefully examine the irregularities which the mica slate there exhibits, in many places, where granite is in the vicinity, and still maintain that the granite was deposited from aqueous solution, his mind must judge very differently from mine of geological evidence. When I began geological investigations many years ago, my prejudices were in favor of the Neptunian theory. But an examination of such localities as I have above referred to, showed me at once that I must change sides, or abandon the mountains and study the subject only in the cabinet. In Massachusetts the mechanical influence of granite upon the neighboring rocks is a hundred times more striking than in the case of greenstone; nor can I conceive how any effects of this kind could have resulted from the deposition of granite from aqueous solution. But they would be the natural results of the protrusion of the granite in a melted state.

It ought, however, to be understood, that in very many places, where the granite and the stratified rocks are in contact, no evidence of the operation of a disturbing force, appears, except the general evidence resulting from the inclined position of the strata. I mean that such cases of disturbance as I have described and sketched, are not common. I explain this in consistency with the igneous origin of granite, by several considerations. In the first place, it is reasonable to suppose, that originally many of the masses of granite that now appear at the surface, were not protruded through the slate; being covered only by those strata which have been subsequently worn away. In such case, almost the only effect which we should expect to find from the forcing upwards of the granite, would be the regular and nearly uniform elevation of the strata; since, if they were of nearly equal thickness and strength throughout, the molten mass beneath would press almost equally against their entire under surface. In the second place, such a molten mass would soften and partially fuse the strata for a considerable thickness above it; and, therefore, it might send veins through the rock thus rendered plastic, without leaving marks of mechanical pressure and disturbance. In the third place, such molten matter would fill all the fissures and cavities previously existing in the stratified rocks without producing disturbance.

These causes, it seems to me, to suggest no others, are sufficient to show why we do not always find evidence of any peculiar disturbance in the strata in contact with granite. But if these strata were not of equal strength or thickness throughout, or if one part of them was less softened by heat than the other parts, then we should expect protrusions of granite to be the result, with traces of mechanical violence; and such probably are the cases which I have sketched. Thus the anomalous as well as the usual modes in which granite occurs, are explicable on this theory: whereas the Neptunian, even if he can show how granite, as it usually occurs, might have resulted from chemical solution in water, cannot by the aqueous theory, explain the anomalies that have been described.

4. *I infer the igneous origin of granite from its chemical effects upon the surrounding strata.*

These effects, so far as I have noticed them in the region I have undertaken to describe, have been detailed in various parts of this Report; and therefore I need only refer to them in a summary manner.

The conversion of graywacke slate into flinty slate, and of certain ferruginous portions of it into jasper, as well as the induration of the limestone in the vicinity of the granite in Newport, R. Island, are undoubtedly the most striking effects of this kind in the region under consideration. I can conceive of no other hypothesis to account for these changes which is not perfectly absurd. Surely no one can think of explaining such facts by any probable operation of an aqueous agency. And if an igneous agency, sufficient to fuse the graywacke and the limestone be admitted, it must have been sufficient also to fuse the granite.

The argument which I have drawn from the existence of apparently semi-fused nodules of the schistose rocks in sienite in favor of the igneous origin of that rock, will apply also to genuine granite on two grounds. 1. Sienite is only a variety of granite; the two rocks being connected in the same continuous mass, even in the very locality where the conglomerated sienite occurs. And I cannot conceive how one part should have had an igneous and the others an aqueous origin. 2. Similar rounded nodules do occur, though less numerously, in granite. (No. 1486.)

I have often noticed an appearance on the surface of granite in contact with mica slate, which I have not seen described; but which seems to have some bearing on this question. The surface of the granite has a striated appearance; as if, when in a plastic state it had been crowded against the slate while at the same time it was urged upwards. Usually a layer of quartz envelopes the granite, and this is often of a bluish or muddy aspect, as if the coloring matter of the slate had penetrated it. These effects, partly chemical and partly mechanical, are easily explicable on the supposition that the granite was protruded in a melted state through the slate, and therefore lends some support to that theory.

Along the western border of the Connecticut valley, the lower beds of new red sandstone in some places have in part lost their red color, so as to become spotted. In the adit, for example, at the Southampton lead mine, the rock has become gray throughout. (No. 167.) Here we know that a large mass of granite exists within a few feet of the sandstone. Now I have shown under greenstone, that just such a change of color results in this same rock, from a contact with greenstone: and scarcely no one now doubts that the heat of the greenstone was the cause. Why then should it be doubted in the case of granite?

5. *I infer the igneous origin of granite from its crystalline structure, and the numerous crystalizations of other substances that have taken place in it.*

These same facts I am aware have been adduced to prove the aqueous origin of granite; for since the products of volcanoes are rarely crystalline, and many splendid crystalizations have taken place from solution in water, it has been thought most reasonable to suppose such was the origin of granite. But when has the chemist been able from aqueous solution to obtain a solid crystalline mass of three or four distinct substances at the same time? I believe never. They always crystalize in succession. And the difficulty is increased when we take into the account the numerous simple minerals that are found crystalized and enveloped in the granite; each of the substances appearing as if they struggled with one another for a place at the moment of deposition.

But on the other hand, if the fused materials of which glass is composed, or melted basalt, or lava, be slowly cooled, they will separate into distinct compounds, as has been done in the case of granite. If, however, they be cooled suddenly, a uniform rock, or even a glass will be the result. Does not this fact lead to the probable conclusion, that the degree of crystalization in any rock depends upon the time employed in its refrigeration. Perhaps, however, other circumstances are concerned in causing such a difference in structure as we find between basalt and granite.

This fifth argument was not adduced to prove the igneous origin of greenstone, because the crystalline structure of that rock is so imperfect compared with that of granite. Some of the other arguments are much more satisfactory in the case of granite than in that of greenstone. And upon the whole, I cannot see why the evidence in favor of the Vulcanian production of granite is not fully as strong as it is in respect to any of the trap rocks. But as to the origin of the latter there is scarcely any diversity of opinion. We may then safely predict that a like uniformity will soon prevail in respect to granite. Indeed, we are informed on the highest authority, that in Great Britain this uniformity of views already exists. Five years ago, Dr. Fitton, President of the Geological Society, said: 'In the speculative department of Geology, nothing has been of late more remarkable with reference to its history in this country, than the *universal adoption* of a modified Volcanic theory, and the complete subsidence, or almost total oblivion, of the Wernerian and Neptunian hypotheses;—so that what, but a few years since, was by some considered as hardihood to propose in the form of conjecture, seems now to be established nearly with the evidence of fact. It is no longer denied, that volcanic power has been active during all the revolutions which the surface of the globe has undergone, and has probably been itself the cause of many of them; and that our continents have not merely been shaken by some mighty subterraneous force, but that strata, originally horizontal, have thus been raised, shattered, and contorted, and traversed, perhaps repeatedly, by veins of fluid matter;—operations which have produced phenomena, so nearly resembling those of volcanic agency, that to have so long disputed the identity of their cause, is one of the most remarkable proofs in the annals of philosophic history, of the power of hypothesis in disturbing or concealing truth.'*

More recently Prof. Conybeare (than whom no higher authority can be quoted in geology,) says that Leibenitz 'attributes the primary and fundamental rocks to the refrigeration of the crust of this volcanic nucleus:—an assumption which well accords with the now almost universally admitted igneous origin of the fundamental granite and with the structure of the primary slates; for the insensible gradation of these formations appears to prove, that gneiss must have undergone in a greater, and mica slate in a less degree, the same action; of which the maximum intensity produced granite.*

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* Anniversary Address, Feb. 15th, 1828.

Brongniart and Beudant also, distinguished professors of geology in Paris, and until recently Wernerians, in their Report on a Memoir of Elie de Beaumont, presented to the Academy of Sciences in 1829, remark as follows: 'The memoir of M. de Beaumont exhibits certainly one of the newest, boldest, and most ingenious theories which have been proposed for a long time. It seems even to demolish those theories which have the honorable prejudice of an illustrious name (Werner) on their side, as well as the general opinion, and which have been adopted by many of the members of this Academy.†

Theory of Central Heat.

The logical mind, that adopts these views of the origin of the unstratified rocks, is irresistibly led to inquire into the commencement and present state of the internal heat which has produced such mighty effects. As to the condition of the globe when this powerful agent began to modify its crust, little more than conjecture can guide our inquiries. Astronomical observations render it probable that the surface of the moon is composed almost entirely of volcanic matter; and that that planet is gradually cooling and passing into a habitable from a state of desolation. Comets also, appear to be in a condition still more chaotic; the matter of which they are composed being actually in some instances expanded into vapor, in consequence of internal heat. The speculative geologist inquires, whether such might not have been the early condition of our globe; and whether it has not been gradually cooling from the beginning to the present time; while such animals have been successively placed upon it as possessed natures adapted to its different temperatures. That its surface must have been torn and ravaged by the most powerful volcanic agency in early times, those who admit the igneous origin of the unstratified rocks must allow: and that its temperature has been sinking, is rendered extremely probable by the almost universal occurrence of animals of a tropical character in the fossiliferous strata of high latitudes.

The surface of the globe has probably nearly or quite reached its maximum of refrigeration, as several facts seem to prove. But what is the present temperature of its internal parts? A great number of observations made within a few years in different parts of the world, in mines and other deep excavations, have brought to light the interesting fact, that the temperature increases rapidly as we descend into the earth: indicating even, that at a depth less than 100 miles, a heat exists great enough to fuse all known rocks; and consequently, that the great mass of the globe beneath this envelope, may now be a molten incandescent mass. Startling as such a conclusion may be, to one who is not conversant with the details and reasonings of geology, it seems to receive confirmation from the occasional ejection of just such melted matter as the theory supposes, from more than 200 volcanoes, which seem to form the safety valves of the vast furnace. And then, still more numerous extinct volcanoes testify to the more powerful operation of this agency in former days. The facility too with which such a theory applies to the explanation of a multitude of physical phenomena, which cannot be here detailed, certainly strengthens the conviction of its truth.

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* Report on Geology, p. 367, (1832.)
† Rapport, &c. 17.

It is but a few years since this theory was formally developed in the scientific world; and although it was viewed by many as the very extravagance of hypothesis, yet it is interesting to see how very rapidly it has gained credence. Nor can this fact be explained without admitting that it carries with it strong marks of truth. The state of opinion on this subject among European geologists, may be learnt from the following paragraph of a recent able French writer on Volcanoes. 'If', says he, 'I have dwelt long on the the ideas of Cordier, it is because they are now professed by the most illustrious geologists of our age. They rest, moreover, on facts so numerous and so well established, that it is impossible not to regard them as a faithful representation of what must have happened at the commencement of things, and of what is now taking place. The hypothesis of central heat, and by consequence that which imputes the origin of volcanic matters to a fiery mass in the interior of the globe, may be placed in the rank of truths the most firmly established. In proportion as observations multiply, this hypothesis is confirmed: the small number of phenomena yet involved in some obscurity, will be explained more easily than those which have been brought to light before: and the systematic minds which still resist the evidence, will soon find themselves compelled to abandon their opinions, which have already fallen into the most profound discredit.'*

'As to the central heat,' says Dr. Macculloch, 'if there is not ample proof of this, I know not that geology can furnish proof of any thing,' &c.†

Even the chemical theory of volcanic action, which imputed it to the oxidation of the metalloids, and which seemed a few years ago to be enlisting able advocates in its defence, appears in Eu-

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[*] Considerations sur les Volcans &c. par M. J. Girardin, Paris, 1831, p. 152.
[†] System of Geology, Vol. II, p. 408.

rope to be nearly abandoned. Even Sir Humphrey Davy, who originally proposed it, subsequently abandoned it; and says that 'the hypothesis of the nucleus of the globe being composed of fluid matter, offers a still more simple solution of the phenomena of volcanic fires than that which has been just developed.'* His surviving brother Sir John Davy, however, still defends the chemical theory, as does also Professor Daubeny. And it ought also to be mentioned, that no longer ago than February 1834, Mr. Greenough, in his Anniversary Address before the London Geological Society, strenuously opposes the igneous origin of granite, and the doctrine of central heat.

Theory of the Sufficiency of Causes now in action, with no increase of intensity, to account for Geological Phenomena.

Although the theory of central heat has been so generally adopted as to excite at present but little discussion, yet a theory has recently been fully and ably developed by a distinguished geologist,† relating to the dynamics of existing causes, which seems likely to elicit much of talent and feeling in its examination. He maintains that if the causes now in operation be supposed to have acted during immense periods of past time, without any increase of intensity, they may have produced all the phenomena which the records of geology disclose. Those who take the opposite ground, are ready to admit that the dynamics of existing causes has been greatly underrated: nor do they suppose that any causes different in their nature from existing ones, have been in operation in past times. But they suppose these causes to have acted with far greater intensity formerly than at present: and they appeal to the following facts in support of this opinion, and in opposition to the theory above stated.

1. The spheroidal figure of the earth renders it probable that it was once fluid. Whether this fluidity was igneous or aqueous, the operation of fire or water must have been far more powerful formerly than at present.

2. Perhaps nine tenths of our present continents exhibit evidence that their stratified rocks were formed beneath the ocean; and they must consequently have been subsequently elevated; and this not by little and little, but by paroxysmal efforts of volcanic force. But that force during the last 4000 years, seems to have been by far too feeble to produce effects to be compared with the elevation of a continent, or even a single mountain chain.

3. The products of volcanic agencies in early times, that is, the unstratified rocks, appear to have been far more abundant than during

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* Philosophical Transactions for 1828, Part II.

† Principles of Geology by Charles Lyell, Esq. Vol. I. London, 1830: Vol. II, London, 1832: Vol. III, London, 1833.

the last few thousands of years. That is, the deposits of granite, sienite, and porphyry, whose cotemporary production can be rendered probable, are of greater extent than those of basalt, greenstone, and trachyte: and these latter more abundant than the lavas of existing volcanoes: thus exhibiting a diminishing energy of volcanic action.

4. A correspondent decrease of violence in this power, is obvious in the disturbances and dislocations of the stratified rocks by the protrusion of the unstratified. That is, the oldest stratified rocks exhibit far more of disturbance than those of more modern date; many of which have not been disturbed at all. This cannot be explained by supposing that the older rocks have been affected by all the paroxysmal efforts of volcanic power that have occurred, whereas the newer ones have felt only the modern throes: for the latter products of volcanic action, such as basalt, greenstone, trachyte, and lava, appear but in a few instances to have disturbed the older rocks.

5. The vents of existing volcanoes are always situated in the midst of regions exhibiting marks of former and extinct volcanic action; and they occupy but a small proportion of those regions; indicating a comparative repose or diminution of the volcanic power.

6. In correspondence with the preceding facts, we find the older rocks, both stratified and unstratified, more crystalline in their structure than the newer ones; an effect which would result from the diminished agency of heat.

7. The character of organic remains implies a like diminution of temperature: nor can the astronomical theory of Mr. Herschel, making this diminution the result of a gradual change in the ellipticity of the earth's orbit; nor the geographical theory of Mr. Lyell, which refers it to variations in the relative position of land and water, and in the elevation and form of land; afford any satisfaction to the mind.

8. The occurence in the sedimentary rocks of immense beds of conglomerate, indicates the occasional recurrence of powerful debacles of water, to form and collect the materials for these rocks. But we know of no cause now in operation adequate to the production of such deluges. Yet if we admit the greater intensity of volcanic power in past times, an adequate cause is provided.

9. Existing diluvium cannot be accounted for by causes now in action. This point, in relation to the diluvium of Massachusetts, has been so fully discussed in the earlier pages of this Report, that I need add nothing further in this place, except to say, that the diluvium of other countries appears to be quite as difficult to be accounted for by the fluvial theory.

Upon the whole, it seems to me that however easily a man may persuade himself in his cabinet, of the truth of the theory that has been examined, he cannot go forth among the mountains without meeting its refutation everywhere; and he must be continually impressed with the vast intensity of force which aqueous and igneous agents have exerted on the globe in former times.

Here terminates my account of the particular rocks of Massachusetts. A few miscellaneous matters that could not properly be introduced in any other place, will be added in conclusion of the Scientific Geology of the State.

MISCELLANEOUS ITEMS.

1. *Origin of Metallic Veins, Beds, &c.*

The metals sometimes occur in the rocks disseminated through their masses: and in this case it is obvious that they must have existed in the materials out of which the rock was produced, and have been separated into small masses by chemical affinities, when the rock was passing from a fluid to a solid state. The same was probably true in those cases where the metals exist in tuberculous masses in the rocks. When they occur in strings, that is, in small veins so numerous as to give the rock a reticulated appearance, they were probably segregated from the mass of the rock at the period of its formation; not improbably filling up the small cracks produced by incipient consolidation. Metallic beds, where the ore is interstratified with the rock, may, in many cases have resulted from aqueous deposition, the ores having been subsequently modified by exposure to heat; as I have more fully suggested in describing talcose slate. But when the metals occur in genuine veins, as they usually do, the theory of their origin is involved in great obscurity. The Wernerian dogma, that all veins were filled by aqueous solution from above, is now exploded; though in a few instances they may have been formed in this manner. A more recent and very ingenious hypothesis represents the contents of metallic veins as having been secreted from the rocks by means of galvanic electricity;* and the change that takes place in its contents as the vein passes into different rocks, certainly lends some plausibility to this suggestion; and it would seem probable that the various layers of rocks and minerals that make up the crust of the globe, must form galvanic combinations of great power. A still more recent hypothesis† imputes metallic veins to sublimation by the internal heat of the earth, which causes the metallic substances to rise into the fissures that exist in the crust of the globe. This hypothesis, also, is very ingenious; but my own mind is not satisfied with any explanation that has yet been proposed.

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* Fox in the Philosophical Transactions for 1830, p. 399.

† Neckar in Philosophical Magazine. Sept. 1832.

I am not aware that any facts which have come to my knowledge relative to the metallic veins in Massachusetts, will throw any light upon this subject. But as yet they have not, except in a few instances, been penetrated far enough to develope facts of much interest.

The direction of these veins is, however, a point that ought not to be passed over in silence. For when we find veins corresponding in direction, especially if in the same formation, we have good reason for presuming that they originated in a common cause, and at the same epoch. On Plate XVI, which shows the direction of the strata in Massachusetts, I have given the course of most of the metallic beds and veins in the State by double arrow heads. The following are the data from which I made the delineation:

		Direction.	Dip.
1.	Bed of Iron in Hawley;	North and South;	Vertical.
2.	do. Somerset, Vt.	do.	20° to 30° East.
3.	Bed of Manganese, Plainfield, (S. W. part,)	do.	nearly 90° East.
4.	Vein of Lead, (most Southerly) Leverett,	do.	nearly Vertical.
5.	do. Whately, (North part,)	do.	do.
6.	Vein of Copper Ore on Island, Turner's Falls,	do.	Westerly.
7.	Vein of Copper Ore in Greenfield, near Turner's Falls,	do.	Vertical.
8.	Vein of Manganese, Conway,	N. E. and S. W.	do.
9.	Vein of Lead, and Copper, Leverett, (most northerly vein,)	do.	
10.	do. do. Southampton,	do. nearly,	do. ?
11.	do. do. Westhampton,	do.	do. ?
12.	do. Zinc chiefly, Northampton,	do.	do.
13. and 14.	Two veins chiefly in Whately,*	do.	
15.	Bed of Copper Ore, Granby, Ct.	do.	20° S. E.
16.	Bed of Mag. Oxide of Iron, Bernardston,	North and South	do.
17.	Bed of Plumbago, Sturbridge,	N. 30° E.	60° to 70° N. W.
18.	do. Iron and Zinc, Sterling,	N. several degrees E.	do.
19.	Vein of Lead, Hatfield,	nearly N. W. and S. E.	Vertical?

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* On Mr. Nash's Authority.

Regarding only the veins in the above table, and judging merely from their course, we should infer that all of them were produced at two epochs, except the single vein in Hatfield. But the great difference between the age of the new red sandstone, containing the copper veins, and that of the granite and mica slate containing the other veins, renders it probable that those in the former rock must have been formed at a different epoch from those of the latter. On this view of the subject we must refer these veins to four periods:—1. The veins of copper, 5 and 6, in the new red sandstone;—2. The veins of lead, 4 and 5;—3. The veins 8, 9, 10, 11, 12, 13 and 14;—4. The vein 19. If the beds be considered as connected in their origin with the veins, the number of epochs of production will not be increased: since the beds, 1, 2, and 3, will belong to the first epoch, and 15, 16, 17, and 18 to the second.

2. *Elevation of the Mountains and Systems of Strata in Massachusetts.*

Geologists who saw that the existing continents of the globe had obviously been raised from the bottom of the ocean, had sometimes suggested that different mountain ridges had been lifted up at different epochs. And they seemed to approach very near sometimes to the discovery of the principle by which they could determine the relative ages of these mountains. But it was reserved for Eli de Beaumont to develope the true principles by which we should be guided in such investigations; and perhaps no discovery in geology within the present century, has excited so much interest among geologists as this. I could not, therefore, be justified in closing my Report without an effort to apply these principles to the mountains and systems of strata in Massachusetts. But as no effort of the kind has been made in this country, I fear that I shall make but a feeble beginning.

Sections and Map of the Direction of the Strata accompanying this Report.

In order to give as correct a view as I am able of the course of our inclined strata and their dip, I have given Plate XVI to illustrate the former, and Plate XVII and XVIII, to exhibit the latter. For on these two circumstances the whole argument for proving the elevation of the different systems of strata at different epochs, rests.

The instruments which I have employed for ascertaining the direction and dip of the strata, are a good pocket compass and a clinometer. I confess, however, that in consequence of the very common oscillation of the dip and direction within short distances, I have been much in the habit of depending upon the *coup d'oeil* to obtain their average: being sure that I knew where the true meridian lay, and having found by long trial that I could be more accurate in this way, and especially in respect to the dip, than by the use of instruments. But after all, every geologist must be aware that all observations of this kind, made in the best manner, can be only approximations to the truth. In most instances, however, they come sufficiently near the truth to form a good basis for reasoning; since it is large differences only, in the dip and direction, on which the conclusions rest.

In strictness, when the direction is given in this Report in degrees, about five degrees should be allowed for the westerly variation of the magnetic needle.

It is only the predominant or general direction of the basset edges of the strata that I have undertaken to give on the Map. The preceding pages of my Report contain numerous local exceptions: but unless these are on a large scale, as in Worcester, Goshen, &c. they have not been represented.

Dotted lines are drawn on the Geological Map of the State, (Plate I,) to show where the sections, given on Plates XVII and XVIII, cross the country. Section A, crosses from east to west near the northern part of the State. Section B, is intended to cross near the middle of the State: though it deviates somewhat from a direct course, in order to strike the granite and coal in Worcester. Section C, passes through the southern part of the State; though when it reaches the northern corner of Rhode Island, it tends more to the south, in order to terminate upon the famous 'Plymouth Rock,' which is a large bowlder of a rather peculiar kind of granite. (No. 1433) Section D, passes from the northeast corner of the State to Boston; thence it changes its course slightly to reach Newport, R. Island. Above sections B and C, a few short sections are introduced of interesting places lying too far north of the line of the general sections to be made part of them. In these minor sections the same scales are employed as in the larger ones.

The horizontal scale used in all these sections corresponds with that on the Geological Map: so that the sections are of exactly the same length as the Map, measured on the dotted lines above described. Hence any particular spot on the section may be found upon the State Map, by laying the one upon the other. The scale for laying off the heights is 1500 feet to the inch. I do not suppose that I have always given the height of the surface with much exactness. I have depended on several surveys that have been executed within a few years for contemplated canals and rail-ways, and on other admeasurements published by individuals, for the height of the most important points along the sections. But in some instances the course of these surveys did not correspond with the line of the sections. In such case I could only approximate to the elevation.

The double scale necessarily employed in extensive sections of this kind, gives so distorted a representation of the surface, and consequently of the relative situation of the different rocks, as exceedingly to diminish the value of such representations. Geologists accordingly at the present day, place but little dependence upon them: or rather they value them less just in proportion to their distortion. 'Such sections,' says De la Beche, 'are little better than caricatures of nature, and are frequently much more mischievous than useful, even leading those who make them to false conclusions, from the distortion and false proportions of the various parts.'* If to this it be added that there is a strong temptation to make up for a deficiency of observation by giving the relative position of rocks according to a favorite theory, we shall be persuaded that a large part of the sections hitherto published, have conveyed to the mind nearly as much error as truth. A section which exhibits only the truth, so far as the observer has ascertained it from actual examination, forms too naked and uninviting a sketch to satisfy the taste or ambition of many. Hence the imagination and the painter are taxed to make up the deficiency.

In the sections appended to this Report, however, I have endeavored to present the dip and superposition of the rocks, only so far as I have determined these points from actual observation. Where for instance, as in the case of the limestone of Berkshire county, I have not seen the actual junction of different rocks, I have left a blank space between them. Notwithstanding these precautions, I am afraid that these sections will convey some erroneous impressions.

The principal object of these sections is to exhibit the actual dip of the strata; and this I have endeavored to give without reference to the distortions of the surface.

Systems of Strata and Mountains of Contemporaneous Elevation in Massachusetts.

A careful examination of the Map and sections that have just been described, will satisfy any one, that although the rocks of Massachusetts belong to several distinct systems of elevation, yet the central ridge, or anticlinal line, of not one of these systems, perhaps, passes through the State. We may, therefore, hope that correspondent parts of these systems may be discovered beyond the limits of the State. But I shall first endeavor to point out, as well as I am able, in chronological order, the different systems that appear within the State.

* Geological Manual, 2d edition, p. 545.

A peculiar difficulty, however, meets us in attempting to ascertain the relative epochs of elevation of our strata; for most of the newer strata are wanting in New England; or rather their number is much less than in some other parts of the world. In the western part of this State, for instance, we have only the new red sandstone and a single tertiary formation, not yet identified with any in other parts of the world, to guide our inquiries in respect to the epochs of elevation. And in the eastern parts of the State, graywacke alone affords us any assistance in this matter; since the plastic clay and every other tertiary formation are so insulated from the older rocks, as to form no grounds for any other than hypothetical conclusions. For these reasons I find it impossible to ascertain the exact place in respect to time, which all the systems of elevation, that I think I discover in the State, ought to occupy. Most of these systems appear to be of great antiquity; corresponding perhaps with the oldest that have been described in Europe.

1. *Oldest Meridional System.* The meeting of the new red sandstone of the Connecticut valley, with the primary strata of Hoosic mountain range, in an unconformable manner, enables us to infer with certainty, that the latter have suffered at least two elevations at different epochs. For the sandstone has a medium easterly dip of 15° or 20°; while the mica slate, talcose slate, and gneiss of the Hoosic range, approach to verticality in their dip. Hence the latter must have received their principal elevation previous to the deposition of the former. There may have been more than one epoch of elevation previous to that time: but we are thus assured of at least one; and the very considerable inclination of the sandstone demonstrates an epoch of elevation subsequent to its deposition. The last elevation seems not to have affected the primary strata on the east side of the Connecticut valley, except perhaps to a limited extent: for the force that raised the sandstone was so applied as to lift up the western edges of the strata: and if there had been a similar force operating on the eastern side of the valley, their eastern edges would also have been thrown up, at least so as to keep them in a horizontal situation, if not to give them a westerly dip.

All the primary strata, therefore, in Massachusetts, west of the valley of Worcester, whose direction is north and south, I regard as belonging to the oldest meridional system: and such is the general direction of all the strata west of Worcester, with the exception perhaps of the argillaceous slate, and associated strata in the north part of Franklin County, whose situation will be more particularly noticed farther on. The Worcester County range of strata may not, indeed, have been elevated at the same time as the Hoosic range: but I know of no facts that will prove that they were not raised at the same epoch; and since the direction of the strata coincides, we must refer them to the same epoch until counter evidence be produced.

I think that an examination of the annexed sections will lead to the impression that the elevating force, or rather the force of plication, which has formed the ridges and furrows of the system under consideration, must have operated in such a manner as to raise up the mountain ridges on the east and west sides of the Connecticut valley, much higher originally than the valley: for amid all the irregularity that is manifested in the dip of the gneiss range east of that valley, we see that the predominant inclination, particularly towards the central and southern parts of the State, is westerly; while on the west side of the valley, it is the reverse; although nearly vertical. This does not prove that the part now occupied by the valley suffered a depression at the epoch under consideration. For even if we suppose it to have been elevated, a valley would have been the result, if the strata on the east and west sides underwent a still greater degree of elevation. At any rate, I think that the actual dip of the strata on the opposite sides of this valley, render it probable, that it was originally a valley of dislocation, and not of excavation: although, as I have argued in other parts of this Report, extensive excavations may have subsequently taken place within its limits.

The fact that the rocks of Berkshire valley have a less dip than those of the Hoosic range, leads naturally to the inference, that they, like the sandstone in the Connecticut valley, were not elevated during the epoch of the oldest meridional system. Yet their dip being considerably greater than that of the sandstone, renders it somewhat doubtful whether the Berkshire rocks were not at least partially elevated earlier than the sandstone: and this fact excites a suspicion that there may have been three epochs of elevation in a north and south direction. The graywacke, however, between Berkshire and the Hudson, has a very high easterly dip, sufficiently great to be regarded as belonging to the oldest meridional system and connected with the Hoosic range. And it is not difficult to conceive how a series of rocks of considerable extent, forming only a part of a system of elevation, may have been tilted up much less than the group generally. So that upon the whole, I am greatly in doubt whether the Berkshire rocks ought to be referred to the oldest or the latest meridional system.

In tracing this oldest meridional system beyond the limits of Massachusetts, it cannot be doubted that all that mountain range from New York to Canada, along the western part of Connecticut, Massachusetts, and Vermont, called in Massachusetts the Hoosic range, and in Vermont the Green Mountain range, constitutes a part of it. Nor can there be any more doubt, that a large part of that broad range forming the eastern side of the Connecticut valley, and extending from Long Island Sound to Canada, at least as far east as a line drawn from the mouth of Thames river through Worcester valley, belongs to the same system. I mean, that if the middle portions of these two ranges belong to the same epoch of elevation, so must their prolongations north and south. The eastern range embraces the highest land in New England; including Wachusett, Monadnock, and the White Mountains. Since these ranges, however, have not been particularly described in New Hampshire and Vermont, other systems of elevation may there be connected with that under consideration. But the continuity of these ridges renders it almost certain that the oldest meridional system extends from one extremity to the other.

According to the best maps, the most elevated parts of the two ranges that have been described, are arranged on a line bearing a few degrees east of north. My own observations on limited portions of their strata in Massachusetts, have not been accurate enough to decide as to their course within a few degrees. I have found the direction of the strata to correspond very nearly with the meridian, except in anomalous cases.

Beaumont, in his *Recherches sur quelques-unes des Revolutions de la surface du Globe,*[*] notices cursorily the system that has now been described; and he remarks, that 'without doubt it belongs to an epoch more ancient than that of the northeast and southwest beds that constitute the Alleganies properly so called.' He, however, makes no distinction between what I call the oldest and the newest meridional system; not being aware probably of any evidence of two epochs of elevation.

In New Jersey and Delaware, primary ranges have been described, running nearly north and south, which have been regarded as a prolongation of those along the banks of the Hudson and the Connecticut. They ought rather to be regarded as parallel ridges, belonging however to the same system: and from some hasty observations which I made several years ago in New Jersey, I am disposed to believe that the new red sandstone there, occupies the same relative situation with respect to the primary rocks, as in the Connecticut valley.

Examining the map of America, we perceive that a considerable part of the Rocky Mountains have a north and south direction, and that such is the general direction of the Andes, as well as of several ridges in South America east of the Andes: and we know that some of these ranges at least, are mainly composed of primary rocks. But in every case, except some of the ridges last named, their difference of longitude is so great as to render it extremely uncertain whether they were elevated at the same epoch as the system that has been under consideration.

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[*] Chap. 2. p. 323

2. *The Trap System.*

The circumstances connected with the greenstone ridges in the valley of the Connecticut, are such as to lead me, with not a little hesitation, to regard them as erupted at an epoch distinct from all the periods in which the other rocks in the State have been elevated. On page 245, I have suggested the reasons that led to the conclusion, that the greenstone began to be protruded through the sandstone during the same time when the upper beds of the sandstone were depositing. Were it not for the occurrence of the trap conglomerate on the upper side of the greenstone, we might allow that the greenstone was protruded at the same time when the sandstone was elevated, or subsequent to that epoch. This circumstance proves that the higher beds of sandstone, or at least a part of them, were deposited subsequent to the elevation of the greenstone: otherwise, how could rounded masses of the greenstone be found in the conglomerated sandstone. But in several places, as at Turner's Falls, and on the southeast side of mount Holyoke, these higher strata of sandstone are much more tilted up than those beneath the greenstone: which seems to indicate that this latter rock forced its way through the sandstone after the deposition of the upper beds. These facts I confess are difficult to be reconciled. But they prove, I think, that the greenstone was elevated at a period (probably at more than one period,) different from that when the sandstone was thrown up.

The prevailing easterly dip of the sandstone containing these ridges of greenstone could not have been the result of the protrusion of the latter rock: for the beds below the greenstone, are, for the most part, quite as much inclined as those above it. This proves that some other agency must have raised the sandstone; except in those few cases alluded to above, where the greenstone seems to have increased the inclination of the strata. Hence only the sandstone in these limited spots can be regarded as belonging to this system of elevation; and it embraces only the trap ranges extending from New Haven to Vermont. These, as may be seen on Plate XV, run in general a few degrees east of north.

I have in another place noticed a limited deposit of new red sandstone and greenstone in Woodbury and Southbury, Ct. This formation resembles exceedingly the analogous sandstone and greenstone in the valley of the Connecticut. The direction of the ridges of greenstone in the Woodbury valley corresponds very nearly, also, with that of the trap in the Connecticut valley; indicating a synchronous protrusion. I omitted, in treating of new red sandstone, to notice a similar formation, about 60 miles long and 30 broad, in New Jersey; and extending northerly into New

York, at least as far as the Palisadoes on the Hudson.* Prominent ridges of greenstone intersect this formation, running from north to south, and resting on sandstone, shale, and conglomerates. Indeed, taken as a whole, the rocks of this region extremely resemble those in the basin of the Connecticut. The inclination of the sandstone, however, is in general rather less in New Jersey, and it is westerly; that is, in a direction contrary to that of the sandstone of the Connecticut valley. Consequently, the mural faces of the greenstone ridges in the latter valley, are on the west side of the ranges; while in New Jersey they are on the east side. But this does not militate at all against the conclusion that the trap ranges in the two formations belong to the same system of elevation. It merely renders it probable that an axis of elevation, or anticlinal line, lies between them.

3. *The Latest Meridional System.*

I have presented the reasons that lead me to suppose the Hoosic mountain range to have been elevated a certain distance before the deposition of the new red sandstone. But the inclination of that rock shows that subsequent to its deposition a second elevation has taken place in the same range. The smallness of the dip in the sandstone, proves that this second elevation must have been small, compared with that which had been previously accomplished in the primary strata west of Connecticut river. Yet there is every reason to believe that this second elevating force acted on all the rocks between Connecticut and Hudson rivers, and probably on those farther west. And very probably much of the greenstone in the Connecticut valley was lifted up along with the sandstone. Hence we are to include in this system all the rocks between Connecticut and Hudson rivers; probably the whole distance between Long Island Sound and Canada. But there is no evidence that the primary rocks east of Connecticut river, which I have included in the oldest meridional system, except in one or two cases of limited extent, were affected by this second elevating agency. For if such had been the case, to as great an extent as on the western side of the Connecticut, the sandstone would either have been elevated without losing its horizontal position, or it would have been tilted up so as to dip in opposite directions on opposite sides of the valley. If then the primary strata east of the river were affected at the epoch under consideration, it must have been in a much less degree than the strata west of the river.

There is, however, in one place, striking evidence that an elevation has taken place in the gneiss east of Connecticut river, since the deposition of the sandstone. I refer to the section which I have given in treating of greenstone, which extends from the greenstone ridges west of Turner's falls, to the primary strata bounding the eastern side of the valley. The change in the direction of the dip of the sandstone as we approach the primary strata, can be explained only by supposing an elevation of those strata after the deposition of the sandstone. At least, the evidence that such was the cause of this anomalous dip, is as strong as the evidence that at the other end of the section the protrusion of the greenstone has occasioned the increased dip of the sandstone. But it is easy to conceive how a protrusion of granite might have taken place in particular places, (and the section shows that granite is associated with the gneiss at the mouth of Miller's river,) and have powerfully affected the incumbent strata for a small distance, without producing a perceptible effect over regions of great extent. And upon the whole, I am inclined thus to explain the case that has been referred to.

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* Pierce in the Am. Jour. of Science, Vol. II. p. 181.

In the Connecticut valley no rock intervenes between the new red sandstone and the newest tertiary. The strata of the latter are horizontal, and were therefore deposited subsequent to the elevation of the system under consideration. Hence we can only say, that the period when this system was developed, was that which intervened between the deposition of the sandstone and the newest tertiary. Beaumont, however, who speaks of this system, as it appears in New Jersey and Delaware, says, that there, 'the chalk formation covers the prolongation of the ancient beds, which are elevated in a nearly north and south direction, and which form the borders of Connecticut and the river Hudson.' If he means, as I suppose he does, that the chalk formation in those states is not dislocated nor elevated, it will follow that the epoch of elevation of this system occurred between the deposition of the sandstone and the chalk.

4. *The Northeast and Southwest System.*

This system embraces in my opinion a considerable part of the mica slate in the valley of Worcester, all the northern part of the gneiss range, which on the east side of that valley trends away to the northeast, and the western part of the graywacke formation, with the talco-chloritic and mica slate in Cumberland, Smithfield, &c. The dip and direction of the strata in the gneiss range exhibit, probably, the most distinct type of this system. They are more uniform in this range than in any other perhaps in the State. The direction is nearly northeast and southwest; though I think rather nearer to north and south than to east and west. The medium dip is from 60° to 70° northwest. In the Worcester mica slate, the dip and direction are much more irregular: though for the most part its strata run nearly northeast and southwest and dip northwest at a large angle. But towards the southern part of the range, they run nearly north and south; and towards the northeast part of the range, they run nearly east and west, conforming apparently to the curve which the western margin of the gneiss forms. The western part of this mica slate range appears to belong to the oldest meridional system that has been described. As to the argillaceous slate, contained in this formation, I suspect that also to be connected with the same meridional system; though I have not observed its dip and direction in places enough to enable me to form a very confident opinion on this point.

I am strongly suspicious, that the mica slate of Worcester valley, will be found to be not perfectly conformable in its stratification to the gneiss on either side of the valley; in other words, that the gneiss was partially elevated previous to the deposition of the mica slate. If so, that epoch of first elevation is probably the oldest in Massachusetts. But there is so much of irregularity in the dip of this rock, that I do not presume to erect another system upon so uncertain a foundation.

An inspection of Plate XV, will show clearly that the graywacke formation belongs to two very distinct systems of elevation; the one running nearly east and west, and the other not far from northeast and southwest. A tract of some width, extending from Walpole to Providence, and indeed to Newport, belongs to the latter system; although on the island of Rhode Island, there is not a little irregularity in the dip and direction. Obviously this part of the graywacke belongs to the northeast and southwest system under consideration. The talco-chloritic slate in Cumberland and Smithfield, also, as well as a part of the mica slate connected with it, appear to belong to the same system; and since the prevailing dip is southeasterly, (although in this there is great irregularity,) it would seem that there may be an anticlinal line between the graywacke and the gneiss east of Worcester, which dips in a contrary direction.

Along the western margin of the tongue of graywacke extending towards Sherburne, the direction of the strata corresponds with this system; for example, in Natick and Watertown, and probably is to be reckoned as a part of it.

The tendency to a northeast and southwest direction, which I have observed in the argillaceous slate of Guilford, Vt. has led me to suspect that this also may belong to the same system. But to render it certain, the formation should be examined farther north, in Vermont and New Hampshire. The mica slate associated with this clay slate on the east, in the southwestern part of New Hampshire, should be examined with the same object in view; for I have observed this also to bear too much to the northeast and southwest to belong to the meridional systems, except as a local anomaly.

I have particularly described under sienite, a limited formation of hornblende slate and mica slate in Whately, running in a direction which corresponds nearly with the northeast and southwest system. If I do not misrecollect, the same series of rocks, embracing serpentine and verd antique marble, west of New Haven, have a similar direction. Perhaps both these cases are insulated parts of this system.

I think it most probable that the northeast and southwest ranges which I have now described, belong to a very extensive system of elevation, of which the Alleghany mountains form a part. Another range of strata of vast extent, doubtless a part of the same system, can be traced from the river Saguenai, 100 miles east of Quebec, to Lake Huron. These consist of gneiss, mica slate, greenstone, sienite, &c., and have been regarded by Dr. Bigsby as the most recent of the primary rocks.* But if we take Beaumont for authority, even these extensive ridges constitute but a moiety of this system. It is his Pyreneo-Appenine system; and it includes the whole of the Pyrenees, a part of the Appenines, the mountains of the Morea, a part of the Hartz Mountains, Mount Atlas, and other ridges in Africa, particularly in Egypt, the Carpathian Mountains, Mount Carmel, and Sinai in Palestine, a part of the Caucasian chain, and of the Ghauts, forming indeed, a set of parallel ridges around the whole globe; and being the most extensive and remarkble system that has yet been traced.

I ought perhaps, however, to suggest the possibility, that the rocks in Massachusetts, which I have described as belonging to this system, may be found connected with some other. For the strata certainly for the most part, run nearer north and south by a few degrees than the general course of the Alleghanies.

I have not found any of the more recent rocks in Massachusetts connected with this system, by which to judge of the epoch of its elevation. We could learn here only that it took place after the deposition of the graywacke. But according to Beaumont, it took place between the deposition of the chalk, and the oldest of the tertiary strata.

5. *East and West System.*

This includes the greater part of the graywacke, granite, sienite, porphyry, and greenstone, in the eastern part of the State; and probably the gneiss in the vicinity of New Bedford. Amid many anomalies, the decidedly predominant direction of the strata of graywacke, (excepting the portions connected with the last system,) is east and west and the dip northerly. Not having made many observations upon the New Bedford gneiss, and finding that sometimes its strata tend northeasterly and southwesterly, I was at first inclined to refer it to the last described system. But more probably I think, it should be connected with the system under consideration.

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* Phil. Mag. Vol. II. N. S. p. 219.

So limited is the graywacke in some portions of the region embraced by this system, as I have stated its boundaries, that it would be desirable to find other evidence that the granite, sienite, porphyry, and greenstone, along the eastern part of the State, belong to the same system of elevation. And fortunately this evidence is presented in the east and west direction of nearly all the mountain ridges and chains of hills composed of these rocks. The most striking example of this fact is the Blue Hills, made up of sienite and porphyry, and forming the most elevated land in the eastern part of the State. The porphyry range a little north of Boston has the same general direction; and so have many smaller ridges to the south of the Blue Hills. In Sharon, Foxborough, &c., however, the sienite ridges assume a direction nearly northeast and southwest, or somewhat nearer to the meridian than this. This is the case with the Moose Hill range, for instance, which is more than 400 feet high, and runs northeast and southwest; and this, with other parallel ridges in that vicinity, obviously belong to the last system of elevation that has been described.* And this is what we might expect, since a portion of the graywacke running through Walpole and Wrentham, and belonging to the northeast and southwest system, occupies the valleys between these ridges.

I have suggested in another place, that the disturbance which the Plastic Clay Formation on Martha's Vineyard seems to have undergone, may have resulted from the protrusion of granite. If so, that granite was probably a portion of the east and west system under description. According to these data, the epoch of its elevation must have been subsequent to the deposition of the Plastic Clay, and consequently later than the epoch of the northeast and southwest system. But I regard this evidence as little better than conjecture; and therefore, I am greatly in doubt as to the period when this system was elevated.

It is natural to inquire whether any traces of this system can be discovered beyond the limits of Massachusetts. The only means I have of forming any conjecture on the subject, consist of geographical maps, which give the direction of chains of mountains: and even in this respect they are so imperfect, as to the more unexplored parts of our continent, that they leave one in much doubt. I will only, therefore, say, that on our best maps, a range of mountains extends along the southern border of Labrador westwards: and that such is the direction of the rivers, which farther west run on the north into Hudson's Bay, and on the south into the bason of the St. Lawrence and great western lakes, as to show that the elevated land, if not mountain ridges, in which these rivers take their rise, have a direction nearly east and west. The same is true of the region west of lake Winnipeck, and of a tract several hundred miles long, on the south side of lake Superior, in which the waters that flow into that lake take their rise.

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*H. E. Rogers in the Report on the Providence and Boston Rail Road, p. 59 and 61.

6. *Northwest and Southeast System.*

No part of the region embracced by the Geological Map (Plate I.) has occasioned me so much perplexity to ascertain the direction of the strata, as that in the vicinity of Blackstone river, near the place where it passes into Rhode Island. The direction of the strata of gneiss there, does not generally differ much from the usual course of the river, and the pretty uniform dip is northeast. Yet sometimes we find them running nearly east and west and dipping north; and this circumstance has led me to inquire, whether they might not in fact be connected with the east and west system. I know not that it is yet settled, how much local causes may alter the direction of strata of the same system in different places. But my present impression is, that the strata under consideration can hardly be connected with the east and west system: and, therefore, I place them provisionally under a sixth system. But I possess no data for forming even a conjecture as to the epoch of its elevation.

In Dr. Richardson's account of the geology of the northwest part of North America, observed during the recent exploring tour under Capt. Franklin, we find him describing a part of the Rocky Mountains as composed of four chains, terminating by the northern ocean to the west of Mackenzie's River, and running about S. E. and N. W. They consist of primary rocks: and I mention them here, as a pretty strong indication that a system of elevation with such a bearing exists on this continent. Such a direction, however, is not common in North America in our mountain chains, unless we go as far south as the isthmus of Darien.

In comparing the facts which have now been stated in regard to the elevation of our strata, with similar facts developed in Europe, I have been led to conclude that it is a considerably longer period since the elevating force has acted in the United States than in Europe. For we have slight evidence of any extensive disturbance here since the deposition of the strata above the chalk, and not very conclusive evidence of such disturbance even so late as the cretaceous period: whereas, in Europe, several systems of elevation are reckoned of a later date. And this conclusion agrees with the fact that volcanic agency has not yet ceased on the eastern continent; but in the United States, no traces of its action, since the earth assumed its present state, have been discovered. For, if I mistake not, the existence of volcanoes in any region, indicates less thickness in the crust of the globe than in other places; since the melted matter would be forced through the envelope where it is thinest. Accordingly, the only experiments that have been made in the United States upon internal temperature, indicate a less rapid increase as we descend into the earth here, than in Europe; and consequently a greater thickness of the earth's crust on this side of the Atlantic.

All this would lead to the conclusion that our western continent is older than the eastern: at least that such is the fact with its Atlantic border. Beaumont, however, seems to be of a different opinion. 'It appears,' says he, 'from the description of Messrs. Vanuxem and Morton, that the ancient level, traced on the flanks of the Alleghanies by the tertiary deposits and the alluvia, anterior to that of existing streams, which cover their base, is no longer horizontal. It rises gradually from New England to the Mississippi, so that at the Isle of Nantucket it plunges beneath the level of the ocean; and from that point even to Greenland, no tertiary deposit has been discovered along the coast. It follows that the American continent has experienced a sort of see-saw movement, (*mouvement de bascule*,) which has raised its western side and sunk its eastern: so that we may attribute a very recent origin to the Andes.' * I confess myself rather sceptical in regard to these conclusions. But even if it be admitted that the western side of this continent is of a comparatively recent origin, it may still be true, that its eastern side was elevated at a very early period.

Ancient Deluges.

If it be true that continents and vast chains of mountains were elevated at different periods, and by paroxysmal efforts, it is impossible but that deluges of tremendous violence and universal extent, should have been the consequence. Accordingly we find traces of such deluges in the vast beds of conglomerates that exist in the sedimentary deposits; and also in the frequent extinctions and renewals of animal and vegetable life, which appear to have taken place on the globe. For such deluges must have been fatal to organized existence: at least to a great extent. But I doubt whether geology is yet enough advanced to be able to trace particular destructions of organized beings to particular epochs of elevation with their attendant deluges. In respect to the rocks of Massachusetts, I feel utterly unable to trace any such connection. Yet our rocks show the occurrence of several very powerful deluges in early times. The earliest of these, by which the materials of the Roxbury and Rhode Island conglomerates were accumulated, must have been of great power: and if, as I suppose, the latter conglomerate was deposited much earlier than the former, two such deluges must have been required. The new red sandstone affords evidence of numerous deluges during its deposition, in the many alternations of coarse and fine materials of which it is composed. Two periods during its production appear to have been particularly distinguished for powerful diluvial action. In the first, those conglomerated beds, made up chiefly of the ruins of granite and associated with the lower beds of sandstone, were accumulated. In the second, that very coarse conglomerate, chiefly composed of various schists and connected with the higher shales and sandstones, was brought into its present situation. The osseous conglomerate connected with the plastic clay indicates diluvial action perhaps, though not of the most violent kind, during the deposition of this formation.

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* Recherches, &c. Chap. 2. p. 321.

Theory concerning the Force by which Systems of Strata were elevated at successive epochs.

Although existing volcanoes often occur at intervals along extensive ridges of mountains, yet there is no evidence that such ridges have been elevated by these volcanoes. Indeed, it is difficult to conceive how a volcanic force can operate except in the direction of the radii of a circle: so that however numerous the *foci*, they could not have produced mountain ridges having a common direction through several degrees of the earth's surface. Volcanic power then, in the common acceptation of the term, could not have produced the systems of elevation that have been examined.

If the theory of internal heat be admitted, however, we are furnished with a power adequate to the production of these systems, as ingeniously suggested by Beaumont. The outer crust of the earth, according to the doctrines of central heat, has nearly reached the limit of refrigeration: at least, it must cool much slower now than the internal parts, if they are intensely heated: and consequently, the internal parts must shrink more than the exterior. Hence the envelope must from time to time become too large to embrace the internal diminished parts, without suffering a degree of plication. That is, in some places the crust will sink down, and in other places be thrown up into correspondent ridges. Mere gravity, would produce this effect, unless the crust had become extremely rigid. And a little reflection will satisfy any one, that these ridges and valleys will correspond in direction with the semi-circumference of the globe; that is, with a great circle upon it: And such is the direction which Beaumont supposes every known system of strata has taken.

According to this hypothesis, we see how it is that mountains should be elevated at different epochs. For they result from the effort which the crust of the globe is caused to make, from time to time, to accommodate itself to the continually diminishing size of the internal nucleus. Whenever a cavity is thus produced underneath any portion of the crust, its weight will cause its thickest or least rigid portions to sink down upon the heated and it may be fluid nucleus, and this will produce a lateral pressure sufficient to elevate adjoining portions, while the weight of the depressed portion will force the fluid matter into the cavities produced by the elevations; and it may be, even cause it to be erupted through the ruptured summits of the ridges; thus producing unstratified rocks, along extensive lines, and not from circular craters, as lava is now erupted from volcanoes. A change of this kind having been effected, all would remain quiet until the secular refrigeration had produced other cavities; when a renewal of the same process would take place. And I think it easy to conceive, that a long series of such changes might take place without so sensibly diminishing the magnitude of the globe, that astronomers should be able to perceive their effects on the earth's rotatory motion through decades of centuries. For the elevation would nearly equal the depression.

From this view of the subject, it would appear that gravity has been the principal force employed to elevate systems of mountains. This, in consequence of the diminished size of the internal nucleus of the globe, would produce a lateral pressure on both sides of that portion of the crust which was depressed, sufficient to elevate adjoining portions; and to force up melted matter beneath and even through the ridges; and thus the ultimate effects would be precisely like that of an expansive force within the earth; except that it would operate along extended lines and not in circular foci.

I am aware that many of the views of Beaumont, which I have attempted briefly to develope, have been, and now are, ably and warmly opposed by Boue and other geologists no less distinguished. All, however, agree, I believe, that different formations, and consequently different mountain masses, have been elevated at different epochs; which I regard as the fundamental and most important principle concerned. Even if it be proved that distant parallel mountain chains were not of synchronous elevation, (which is the principal point at issue,) it cannot materially affect the value of Beaumont's researches. He certainly has the merit of bringing together all that was known on this subject and of deducing from thence some masterly generalizations, which must be regarded as forming an interesting epoch in geology.

Conclusion.

In drawing to a conclusion this protracted Report on the geology of Massachusetts, it is natural to pause and look back upon my labor. And I freely acknowledge that its great deficiency and imperfection are its most striking features. I cannot, indeed, accuse myself of a want of diligence and effort to accomplish the objects of my appointment. It is now a little more than three years since I received my commission; and during that period, in addition to the ordinary labors of my profession, I have travelled 4550 miles for geological purposes, and collected for the Government and for the three Colleges in the State, nearly 5000 specimens of rocks and minerals: 1550 of which belong to the Government collection. Yet I cannot but perceive great imperfections and deficiencies in my account of our rocks: and I have become more and more impressed with the idea, that a much longer period was indispensable to enable any man to obtain a full and complete account of the geology and mineralogy of nearly 8000 square miles of surface, so diversified as Massachusetts. Indeed, had I not, previous to receiving my commission, travelled nearly as far, and obtained nearly as much information relative to our geology, as since that period, my Report could hardly have been tolerable, if it be so now. As it is, I can regard it only as a commencement of the work of exploring our rocks and minerals. The field yet remains open for the admission of other and more able laborers, who, I doubt not, may reap many an abundant harvest. If my efforts shall aid or encourage those who may come after me, they will not have been made in vain.

I cannot close without expressing to your Excellency, how gratifying it has been to me, to act in this whole business, under the direction of one whose views have been so liberal in regard to it; whose counsels and instructions have been so judicious and encouraging; and whose personal attention and kindness have laid me under very strong obligations.

Nor can I omit to mention the universal disposition which I have found manifested by all classes of the citizens of the Commonwealth, and in every part of it, to do all in their power to forward the objects of my commission. This is among the circumstances that gave so much interest to all my geological tours, and renders the retrospect of them among the most delightful recollections of my life. These excursions, I am happy to confess, have greatly exalted my opinion of the kindness, intelligence, and happy condition of our population, and sensibly increased my attachment to my native State.

Finally, and above all, I would not close without acknowledging my supreme obligations to Him, whose providential care and kindness have followed me in all my wanderings, not permitting even a hair of my head to be injured; and who has enabled me to bring at length to a conclusion, one of the most laborious enterprises of my days. To Him I desire to consecrate the fruits of this labor and of all the subsequent labors of life. And should they prove even slightly instrumental in promoting human knowledge and happiness—two grand objects of the Divine Benevolence—I know that they will be accepted.

Respectfully submitted,

EDWARD HITCHCOCK.

Amherst College, September 1, 1833.

A CATALOGUE

OF THE

ANIMALS AND PLANTS

IN

MASSACHUSETTS.

PART IV.

To His Excellency Levi Lincoln, Esq.
Governor of Massachusetts.

In executing the part of my commission which directed me to furnish catalogues 'of the native mineralogical, botanical and zoological productions of the Commonwealth,' I have been greatly dependant upon the assistance of several gentlemen distinguished for their acquaintance with particular branches of natural history. Their names will be found prefixed to the catalogues which they have furnished. And I take this opportunity to testify to the prompt and liberal manner in which they have executed this difficult task. I ought also to remark, that the catalogues which follow, being for the most part the first that have been attempted in this quarter of the country, cannot be supposed perfect or complete. They are sufficiently so, however, to furnish a great amount of new and valuable information respecting the organized beings found within the limits of the State.

In respect to the minerals of the State, I have found it more convenient to give an account of them in describing the several rocks in which they occur, and also in the Tabular View of the rocks appended to the Atlas; and I judge it wholly unnecessary to repeat the list in this place.

Respectfully Submitted,

Edward Hitchcock.

Amherst College, October 1. 1833.

ANIMALS IN MASSACHUSETTS.

I.—MAMMALIA:

OR ANIMALS WHICH SUCKLE THEIR YOUNG.

In preparing the following Catalogue of our mammiferous animals, I have been permitted to make free use of notes kindly furnished by Dr. T. W. Harris; a gentleman so well known as an accurate zoologist, that the value of this Catalogue would have been much enhanced, could he have been persuaded to make it entirely his own.

ORDER I.—CARNASSIERS.

- Vespertilio.
  - pruinosus, Say. *Hoary Bat.*
  - noveboracensis, Linnaeus. *Red or New York Bat.*
- Sorex.
  - brevicaudus, S. *Short tail Shrew.*
- Scalops.
  - Canadensis, Cuvier. *Mole.*
- Condylura.
  - cristata, Desmarest. *Star-nose Mole.*
  - macroura, Harlan. *Thick-tailed star-nose Mole.*
- Ursus.
  - Americanus, Pallas. *Black Bear.*[*]
- Procyon.
  - lotor, L. *Raccoon.*
- Gulo.
  - luscus, L. *Wolverene.*[†]
- Mustela (Putorius.)
  - vulgaris, L. *Weasel*[‡]
  - erminea, L. *Ermine*[‖]
  - Canadensis, L. *Fisher Weasel.* (Dr. Emmons)
  - ?martes, L. *Pine Martin.*
  - vison, L. (lutreola, Harlan and Godman.) *Mink.*
- Mephitis.
  - Americana, Desmarest. *Skunk.*
- Lutra.
  - Canadensis, Sabine. (Brasiliensis, Harlan and Godman.) *Land Otter.*
- Canis.
  - (Lupus) occidentalis, Richardson. *Wolf.*

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[*] The long-legged variety is most common on Hoosic mountain, but the short-legged variety has been killed there according to Dr. Emmons.

[†] On Hoosic mountain rare—Dr. Emmons.

[‡] The Weasel becomes white in the winter like the ermine, from which it is not distinguished by hunters.

[§] The ermine in its summer dress, greatly resembles the weasel.

Canis.

(Vulpes) fulvus, D. *Red-Fox.*
Virginianus, Gmelin. (cinereo-argentatus, Say and Godman.) *Gray-Fox.*

Felis.

? concolor, L. *Cougar, Panther, Painter or Catamount.*
Canadensis, Geoffrey. *Lynx, or Wild-Cat.*

Phoca.

vitulina, L. *Common, or hair-Seal.*
cristata, L. *Hooded Seal.*

ORDER II.—RODENTIA.

Castor.

? fiber, L. *Beaver.*

Fiber.

zibethecus, L. *Musquash.*

Arvicola.

? Pennsylvanica, Ord. *Meadow-Mouse.*

Mus.

decumanus, Pallas. *Common Brown, or Norway-Rat, Wharf-Rat, Water-Rat.*
rattus, L. *Black-Rat.*
musculus, L. *Mouse.*
? leucopus, Rafinesque. (agrarius, Godman.) *Field Mouse.*

Gerbillus.

(Meriones) Canadensis, D. *Jumping Mouse. Deer Mouse.*

Arctomys.

monax, Gmelin. *Woodchuck.*

Sciurus.

cinereus, L. *Cat Squirrel.*
Carolinensis, Gmelin. *Gray Squirrel.*
niger, L. *Black Squirrel.*
Hudsonius, Gmelin. *Chickaree or Red Squirrel.*
(Tamias) striatus, Klein (Lysteri, Ray, and Richardson) *Striped or Ground Squirrel.*

Pteromys.

volucella, L. *Flying Squirrel.*

Hystrix.

pilosus, Catesby. (dorsata L.) *Porcupine.*

Lepus.

Americanus, Gmelin. *Rabbit, or Hare.* *
Virginianus, Harlan. (variabilis, Godman) *Varying Hare.*

ORDER III.—RUMINANTIA.

Cervus.

Virginianus, Gmelin. *Common or Fallow Deer.*

ORDER IV.—CETACEA.

Delphinus.

Delphis, L. *Grampus or Porpus.* †
(Phocæna) gladiator, Lacepede. *Killer, Sabre-finned Dolphin, or Sword Fish.*

Balæna.

mysticetus, L. *Common Whale.*

Note.—It is doubtful whether the animals, to the names of which this character (?) is prefixed, do now exist within the limits of Massachusetts: all of them, however, except Mustela martes, Arvicola Pennsylvanica, and Mus leucopus, undoubtedly once had here a 'local habitation.'

* This animal is almost universally called a *Rabbit*, though it is, strickly speaking, a Hare, and never burrows like a Rabbit.

* Not unfrequently but improperly called Porpus. It is the true *Dolphin* of the ancients but not the Dolphin of Seamen. which is the Corphæna purpurea,

II.—BIRDS.

BY EBENEZER EMMONS, M. D.

Professor of Natural History in Williams College.

Explanations and Abbreviations.

‖ placed before a species denotes that it is a summer and winter resident.
¶ marks the rare species.
§ shews that it is a regular visitant, and breeds in this climate.
† shews that it is an occasional visitant.
L.—Linnæus. Briss. Brisson. Gm. Gmelin.
Lath.—Latham. Ill.—Illiger. Cuv.—Cuvier. Vieill.—Vieillot.
Temm. Temminck. Ranz.—Ranzani. Latr.—Latreille.
Wils.—Wilson. Bon.—Bonaparte.

SUB CLASS I.

Hind toe articulated on the same plane with the foretoes, and bearing on the ground the whole length, *formed for grasping.*

ORDER I.—ACCIPITRES.

Accipitres. L. Gm. Lath. Cuv. Vieill. *Raptatores,* Ill. *Rapaces,* Temm. Latr. Ranz.

Falco.
‖¶ fulvus, *Ring-tailed Eagle.*
†¶ Washingtonianus, Aud. Winter.
‖¶ leuco cephalus, L. *Bald Eagle.*
† haliætus, L. *Fish Hawk.* Makes its visits up the Hoosic in the spring.
§ sparverius, L. *Sparrow Hawk.*
§ columbarius, L. *Pigeon Hawk.*
¶ palumbarius, L. *Goshawk.*
§ velox, Wils. *Slate-colored Hawk.* Common. Arrives March 20th.
¶ lagopus, L. *Rough-legged Falcon.*
‖ borealis, Gm. *Red-tailed Hawk.* Common. Prepares its nest early in March.
‖ hiemalis, Gm. Wils. *Winter-Falcon.*
† Islandicus,
† peregrinus,
† atricapillus, Wils.
† fuscus, Gm.
† sancti—Johannis, Gm. Winter.
luteoides, Nutt.
Harlani?
cyaneus, Lin.

Strix.
†¶ funerea, Gm. *Hawk Owl.* Autumn.
‖¶ Virginiana, Gm. *Great-horned Owl.* Inhabits the mountains.
§ otus, L. *Long-eared Owl.*
§ brachyotus, Gm. *Short-eared Owl.* Common.
¶‖ Acadica, Gm. *Little Owl.*
† nyctea, Lin. *Snowy Owl.*
‖ asio, L. *Little Screech Owl.*
†¶ cinerea, Gm. *Great Gray Owl.*
‖ nebulosa, *Barred Owl.*
‖ flammea, Lin. *Barn Owl.*

ORDER II.—PASSERES.

TRIBE I.—SCANSORES.

Family Amphiboli.

Coccyzus, Vieill Temm. Ranz. Cuv.
Cuculus, L. Briss. Gm. Lath. Ill.
§ Americanus, Bon. *Yellow-billed Cuckoo.*

Cuculus.
§ erythrophthalmus. *Black-billed Cuckoo.*

Family Sagittilingues,

Picus, L. Briss. Gm. Lath. &c.
§ auratus,L. *Golden-winged Woodpecker.* Common.—Arrives about April 10. and migrates south in Oct.
‖ pileatus, L. *Pileated Woodpecker.*
§ erythrocephalus, L. *Red-headed Woodpecker.*
† Carolinus, L. *Red-bellied Woodpecker* * Common near Rochester N. Y.
§ varius. L. *Yellow-bellied Woodpecker.*
‖ villosus, L. *Hairy Woodpecker.*
‖ pubescens, L. *Downy Woodpecker.*

TRIBE II.—AMBULATORES.

Family Angulirostes, Ill.

Alcedo, L. Gm. Lath.
§ alcyon, L. *Belted King Fisher.*

Family Gregarii.

Sturnus, L. Briss. Gm.
§ Ludovicianus, L. *Meadow Lark.* Arrives abut March 13th.
Icterus, Briss. Temm. Ranz.
§ Baltimore, Dand. *Baltimore Oriole.*
§ spurius, Bon. *Orchard Oriole.*
§ Phœniceus, Dand. *Red Winged Starling.* March 20th.
§ pecoris, L. *Cow Banting.*
§ agripennis, Bon. *Rice Banting.*
Quiscalus, Vieill.
§ versicolor, Vieill. *Purple Grakle.*
ferrugineus, Bon. *Rusty Grakle.*
† baritus, Bon. *Black Oriole.*
Corvus. L. Gm. Lath. Cuv.
‖ corone, L. *Crow.*
corax? *Raven.*
‖ cristatus, L. *Blue Jay.*

Family Sericati.

Bombycilla, Briss. Ill.
§ Carolinensis, Briss. *Cedar Bird.*

Family Chelidones.

Caprimulgus, L. Briss. Gm. Lath.
§ vociferus, Wils. *Whip-poor-will.*
§ Virginianus, Briss. *Night-Hawk.* Arrives March 20th.
Cypselus, Temm.
§ pelasgius, Temm. *Chimney Swallow.*
Hirundo, L. Briss. Gm. Lath.
§ purpurea, L. *Purple Martin.*
§ rufa, Gm. *Barn Swallow.* Arrives April 20th.
§ fulva, Vieill. *Rocky Mountain Swallow.* Common.
§ riparia, L. *Bank Swallow.*
bicolor, Vieill.

Family Canori, Ill.

Muscicapa, Briss. Ill. L. Gm.
§ tyrannus, Briss. *Tyrant Fly-Catcher.* Arrives between 1st and 12th May.
§ crinita, L. *Great crested Fly-catcher.*
§ fusca, Gm. *Pewit Fly-catcher.* Arrives March 20th.
§ virens, L. *Wood-Pewee Fly-catcher.*
§ ruticilla, L. *American Fly-catcher.* Common.
‖ Cooperi, Nutt. *Olive Sided Fly-catcher.*

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* Takes the place of the P. auratus in the western part of the State of New York.

Icteria, Bon.
† viridis, Bon. *Yellow-breasted Chat.* First of September.
Vireo, Vieill.
§ gilvus, Bon. *Warbling Vireo.*
§ flavifrons, *Yellow-throated Fly-catcher.*
¶ noveboracensis, Bon. *White-eyed Fly-catcher.*
§ olivaceus, *Red-eyed Fly-catcher.* Common.
Lanius, L. Briss. Gm. Lath.
† septentrionalis, Gm. *Butcher Bird.* Late in Autumn.
† excubitoroides, Swainson. *American Gray Strike.* Winter.
Turdus, L. Briss. Gm.
† polyglottos, L. *Mocking Bird.* Very rare in the Spring.
§ felivox, Vieill. *Cat Bird.* Arrives between May 1st and 12th.
§ migratorius, L. *Robin.* Arrives March 10th.
§ rufus, L. *Ferruginous Thrush..*
§ mustelinus, Gm. *Wood-thrush.* Arrives May 1st to 12th.
§ minor, Gm. *Hermit Thrush.* Arrives May 1st to 12th.
Wilsonii, Bon. *Tawney Thrush.* Do. Do.
† noveboracensis, Nutt. Autumn.
Sylvia. Lath. Temm. Ranz.
§ aurocapilla, Bon. *Golden Crowned Thrush.* May 1st to 12th.
noveboracensis, Lath. *Water Thrush.*
† coronata, Lath. *Yellow-rump Warbler.* Passes north in the Spring, returns in Sep.
virens, Lath. *Black-throated Green Warbler.*
¶§ Blackburniae, Lath. *Blackburnian Warbler.* Mountain.
¶ icterocephala, Lath. *Chesnut-sided Warbler.* Do.
§¶ castanea, Wils. *Bay-breasted Warbler.*
striata, Lath. *Black-poll Warbler.*
§¶ varia, Lath. *Black and White Creeper.* Mountain.
§¶ tigrina, Lath. *Blue Mountain Warbler.*
§ æstiva, Lath. *Blue-eyed Yellow Warbler.*
§ Americana, Lath. *Blue Yellow-back Warbler.*
†¶ Canadensis, Lath. *Black-throated Blue Warbler.*
¶ agilis. *Connecticut Warbler.*
† autumnalis, *Autumnal Warbler.* Returns from the North in Oct.
† petechia, Lath. *Yellow red-poll Warbler.*
§ maculosa, Lath. *Spotted Warbler.*
† pardalina, Bon. *Canada Warbler.*
† auricollis? *Orange-throated Warbler.*
§ pinus, Lath. *Pine Warbler.*
§ trichas, Lath. *Maryland Yellow Throat.*
† trochilus, Lath. *Yellow Titmouse.*
§ sphagnosa Bon.
solitaria? *Blue-winged Yellow Warbler.*
Certhia.
§ familiaris, Lin. *Brown Creeper.*
Saxicola, Temm. Ranz.
§ sialis, Bon. *Blue Bird.* Ar. about Mar. 10.
Regulus, Vieill.
§ cristatus, Vieill. *Golden crested Wren.*
Troglodytes.
§ ædon, Vieill. *House Wren.*
§ brevirostris, Nutt. *Short billed Marsh Wren.*

Family Tenuirostres.

Sitta, L. Briss. Gm. Lath.
§ Carolinensis, Briss. *White-breasted Black-capped Nutach.*
§ Canadensis, L. *Red-bellied Nutach.*
Anthus.
spinoletta, Bon. *Brown or Red Lark.*
Alauda
alpestris, Lin. Wils. *Shore Lark.*

Family Anthomyzi.—Ranz.

Trochilus, L. Gm. Lath.
§ colubris, L. *Hummnig Bird,*

Parus, L.
‖ articapillus, L. *Black-capped Titmouse.*

Family Passerini.—Ill.

Emberiza, L. Briss. Gm.
† nivalis, L. *Snow Bunting.* Winter.
† Americana, Wils. *Black-throated bunting.*

Tanagra, L. Gm. Lath. Cuv.
rubra, L. *Scarlet Tanager.*

Fringilla, L. Temm. Ranz. Wils.
§ cyanea, Wils. *Indigo Bird.* Common.
¶ § Pennsylvanica, L. *White-throated Sparrow.*
§ graminea, Gm. *Bay Winged Bunting.* Common.
§ melodia. Wils. *Song Sparrow.*
‖ hiemalis. *Snow Bird.* Breeds in the mountains: common in the hedges in Spring and Autumn.
¶ passerina, Wils. *Yellow Winged Sparrow.*
† Canadensis, Lath. *Tree Sparrow.* Winter.
† socialis, Wils. *Chipping Sparrow.*
§ pusilla, Wils. *Field Sparrow.* Common.
§ tristis, L. *Yellow Bird, or Goldfinch.*
§ pinus, Wils. *Finch.*
†¶ linaria, *Lesser red-poll.* Winter.
† illiaca, Merrem. *Fox-colored Sparrow.* Winter.
leucophrys, Temon. *White-crown Bunting.*
ambigua, Nutt. *Ambiguous Sparrow.*
§ savanna, Wils. *Savannah Sparrow.*
† savannarum, Gm. *Savannah Finch.*
§ palustris, Wils. *Swamp Sparrow.*
§ maritima, Wils. *Sea-side Finch.*
§ juncorum, Nutt. *Bush Sparrow.*
§ erythrophthalma, L. *Towhe Bunting.*
¶ cardinalis, Bon. *Cardinal Grosbeak.*
§¶ rosea, Bon. *Rose-breasted Grosbeak.*
enucleator, Wils. *Pine Grosbeak.*
leucoptera, Gm. *White-winged Cross-bill.*
¶ purpurea, Gm. *Purple Finch.*

Loxia. Briss. L. Gm. Lath.
curvirostra, L. *American Cross-bill.*

Family Columbini.

Columba.
§ migratoria, L. *Passenger Pigeon.*
¶ Carolinensis? L. *Turtle Dove.*

SUB CLASS, II.

Hind toe articulated higher on the tarsus than the fore toes; incapable of grasping, or wanting.

ORDER III.—GALLINÆ.

Family Gallinacei.

Meleagris.
¶‖ gallopavo, L. *Wild Turkey.* Now become scarce and nearly extinct.*

Perdix, Bris. Lath. Ill.
§ Virginiana, Lath. *Quail.*

Tetrao, L. Gm. Lath. Ill. Cuv.
‖ umbellus, L. *Ruffled Grous.* Common.
§ cupido, Lin. Wils. *Pinnated Grous.*

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* Frequently met with on Mt. Holyoke. E. H.

ORDER IV.—GRALLÆ.

Family Pressirostres.

Charadrius, L. Gm. Lath. Ill.
† semipalmatus, Bon. *Ring Plover.* A single specimen on the banks of the Hoosic.
§ melodus, Ord. *Ringed Plover.*
§ vociferus, L. *Kildeer Plover.* Appears about April 10th.
§ pluvialis, L. *Golden Plover.*
§ helveticus,
Calidris.
† arenaria, Ill. *Sanderling Plover.*
Strepsilas, Ill. Temm. Ranz.
§ interpres, Ill. *Turn-stone.*
Hæmatopus.
¶† ostraligus, Lin. Wils. *Red Oyster Catcher.*

Family Herodii. Ill.

Grus, Pallas. Ill. Cuv. Temm.
¶§ Americana, Temm. *Hooping Crane.*
¶ Canadensis, *Brown Crane.*
Ardea.
§ herodias, L. *Great Heron.*
§ alba, L. *Great white Heron.*
§ nycticorax, L. *Night Heron.* More common late in the Summer.
cœrulea, L. *Blue Heron.*
minor, Wils. *American Bittern.*
§ virescens, *Green Heron.*
¶ exilis, *Least Bittern.*
Recurvirostra.
Americana? *American Avoset.*
Ibis.
falcinellus, Vieill. *Glossy Ibis.*

Family Limicolæ.

Numenius. Briss. Lath. Ill. Cuv.
§ longirostris, Wils. *Long-billed Curlew.* Rarely on the Hoosic.
† Hudsonicus, Lath. *Esquimaux Curlew.*
borealis, Lath.
Tringa. L. Lath. Gm.
§ semi-palmata, Wils. *Semi-palmated Sandpiper.*
alpina, L. *Red-backed Sandpiper.*
pectoralis, Bon. *Pectoral Sandpiper.*
§ pusilla, Wils. *Little Sandpiper.*
§ Schinzii, Bon. *Schinzii's Sandpiper.*
rufescens, Vieill. *Buff-breasted Sandpiper.*
minuta? *Pigmy Sandpiper.*
Wilsonii, Nutt. *Wilson's Sandpiper.*
cinerea, Lin. Wils. *Ash-colored Sandpiper.*
Himantopus. Briss. Ill. Cuv. Temm.
nigricollis, Vieill. *Long-legged Avocet.*
Totanus. Cuv. Temm. Vieill. Ranz.
melanoleucus, Vieill. *Tell-tale Godwit.*
¶ macularius, Temm.
§ semipalmatus, Temm. *Willet.*
§ flavipes, *Yellow-shank Tatler.*
† chloropygius, Vieill. *Green-rump Tatler.*
Limosa.
† fedoa, Vieill. *Great Warbler Godwit.*
† Hudsonice, Swainson. *Hudsonian Godwit.*
Scolopax. L. Briss. Gm. Lath.
Wilsonii, Temm. *Snipe.*
† grisea, Gm. Lath. *Red-breasted Snipe.*
§ minor, Gm. Bon. *Lesser Woodcock.*

Rallus, L. Cuv. Vieill.
¶ Virginianus, L. *Virginia Rail.*
† Carolinus, Bon. *Rail.*
¶ Noveboracensis, Bon. *Yellow Breasted Rail.*

Fulica.
Americana, Gm. *Common Coot.*

Phalaropus.
¶ fulicarius? Bon. *Red Phalarope.*

ORDER V.—ANSERES.

Family Longipennes.

Rhincops, L. Gm. Lath.
§ nigra, L. *Black skimmer or Shear-water.* Visits the coast during Summer.

Sterna.
§ hirundo, L. *Great Tern.*
§ minuta, *Lesser Tern.*
§ angelica, Montagu. *Marsh Tern.*
¶ Dougalli, Montagu. *Roseate Tern.*

Larus.
‖ capistratus, Temm. *Brown marked Gull.*
§ atricilla, L. *Black headed Gull.*
§ canus, L. *Common Gull.*
§ fuscus, L. *Silvery Gull.*
argentatoides, Brehm. Common near N. Y.
† Bonapartii, Swainson and Richardson. *Bonapartean Gull.*
cataractus, Lath. *Skua Gull.*

Family Lemallosodentati.—Ill.

Anser.
Canadensis, Vieill.
hyperboreas, Pallas. *Snow Goose.*
bernicla, Bon. *The Brant.*

Anas, L. Gm. Briss.
† clypeata, L. *Shoveller.*
† boschas, L. The *Mallard.*
§ acuta. *Pintailed Duck.*
Americana. *Widgeon.*
† sponsa. *Wood Duck.*
discors. *Blue Winged Teal.*
† streptera, Lin.
† crecca, Bon. *American Teal.*

Fuligula, Bon.
perspicillata, Bon. *Black or Surf Duck.*
vallisneria, Stephens. *Canvass-back Duck.*
clangula, Bon. *Golden Eye.* Rare on the Hudson.
albeola, Bon. *Buffet-headed Duck.*
¶ spectabilis, Bon. *King Duck.*
Americana, Swain. and Richard. *American Scoter Duck.*
† nigra, Bon. *Scoter Duck.*
† marila, Stephens. *Scoup Duck or Blue Bill.*
† glacialis, Bon. *Long-tailed Duck.*

Mergus, L.
Merganser. *Goosander.*
serrator, Lin. *Red-breasted Merganser.*

Sula.
bassana, Lacep. *Gannet.*

Podiceps, Temm. Vieill.
† cristatus, Lath. *Crested Grebe.* Rare on the Hudson.
† Carolinensis, Lath. *Pied-bill Dob-chick.*

Podiceps.
† cornutus? Lath. *Horned Grebe.*
minor, Lath. *Little Grebe.*
Colymbus.
§ glacialis, L. *Great Northern Diver or Loon.*
† septentrionalis, L. *Red-throated Diver.*
Uria.
† alle, Temm. *Little Auk.*
Mormon, Ill.
† arcticus, Ill. *Puffin.*
Alca, L, Gm. Briss.
torda, L. *Razor-bill.*
Phalacrocorax.
† graculus, Dumont. *The Shag.*

III.—REPTILIA, OR REPTILES.

BY DAVID S. C. H. SMITH, M. D.

ORDER I.—CHELONIA.—BRONGNIART.

Testudo, L.
scabra, Shaw. *Common Turtle.*
Pennsylvanica. *Box Turtle.*
serpentina. *Snapping Turtle.*
picta, Schœpf. *Painted Turtle.*
punctata, Schœpf. *Speckled Turtle.*
clausa, } On the authority
insculpta, Leconte. } of Dr. Emmons.

ORDER III.—OPHIDIA.—BRONG.—SERPENTS.

Coluber.
constrictor, L. *Black Snake.*
ordinatus, L. *Striped Snake.*
sipedon, L. *Water Snake.*
saurita, L. *Ribbon Snake.*
sirtalis, L. *Garter Snake.*
striatulus, L.
punctatus, L.
eximus, Dekay. *House Snake.*
vernalis, Dekay. *Green Snake.*
Crotalus.
durissus, L. *Banded Rattle-Snake.*

ORDER IV.—BATRACHIA.—BRONG.

Rana, L.
pipiens, L. *Bull Frog.*
clamata, Dand. *Bawling Frog.*
flavi-viridis, Harlan. *Spring Frog.*
sylvatica, Le Conte. *Wood Frog.*
palustris, Le Conte. *Leopard Frog*
Hyla, Laur.
squirella? Dand. *Peeping Frog of New England.*
versicolor, Le Conte. *Common Tree Toad.*
Bufo.
musicus.
and one not described.

Salamandra, Brong. *Salmanders or Slows.*
- subviolacea, Barton.
- faciata, Green.
- erithronota, Raf.
- cinerea, Green.
- symetrica, Harlan.
- tigrina, Green. } On the authority
- longicauda, Green. } of Dr. Emmons.
- picta, Harlan.

IV.—FISHES.

A Catalogue of the Marine and Fresh-water Fishes of Massachusetts.

BY JEROME V. C. SMITH, M. D.

CLASS I.—CARTILAGINOUS FISHES.

ORDER I.—CYCLOSTOMI.

Petromyzon.
- marinus. *Sea Lamprey-eel.*
- fluviatilis. *Fresh-water Lamprey-eel.*

ORDER II.—SELACHII.

Scyllium.
- canicula. *Sea-dog, or Dog Shark.*
- catulus. Very similar in character and appearance.

Squalus.
- canis. *Dog*,—by some called the *Mad Sea Dog.*

Carcharias.
- vulgaris. *White Shark.*
- glaucus. *Blue Shark.*
- vulpes. *Fox-Shark*, or *Thrasher.*

Zygæna.
- vulgaris. *Hammer-Headed Shark.*
- tiburo. *Warty Shark.*

Selache.
- maximus. *Basking Shark.*

Torpedo.
- vulgaris. *Torpedo*, or *Benumbing Fish.*

Raia.
- clavata. *Thornback.*
- batis. *Skate.*

Trygon.
- pastinaca. *Sting Ray.*

ORDER III.—STURIONES.

Accipenser.
- sturio. *Sturgeon.*

CLASS II.—OSSEOUS FISHES.

ORDER IV.—PLECTOGNATHI.

Aluteres.
- monoceros. *File Fish.*

Ostracion.
- triqueter. *Trunk Fish.*
- bicaudalis.

Tetraodon.
- turgidus. *Swell Fish.*

ORDER V.—LOPHOBRANCHII.

Syngnathus.
typhle. *Little Pipe Fish.*

ORDER VI.—MALACOPTERYGII—ABDOMINALIS.

Family I.—Salmonides.

Salmo.
salar. *Salmon.*
trutta. *Salmon Trout.*
fario. *Common Trout.*
hucho. *Hunchen Trout.*

Osmerus.
eperlanus. *Smelt.*

Family II.—Clupea.

Clupea.
harengus. *Common Herring.*
menhaden, *Menhaden.*
alosa. *Shad.*
vernalis. *Alewife.*
minima. *Brit.*

Family III.—Esoces.

Esox.
lucius. *Pickerel.*
belone. *Sea Pike.*

Exocetus.
mesogaster. *Flying Fish.*

Family IV.—Cyprinidæ.

Cyprinus.
auratus. *Golden Carp.*
crysolencas. *Shiner.*
atronasus. *Minow.*
oblongus. *Chub.*
teres. *Sucker.*

Abramis.
chrysoptera. *Bream.*

Leuciscus.
rutilus. *Roach.*
vulgaris. *Dace.*
alburnus. *Bleak.*
cephalus. *Short Chub.*

Family V.—Siluridæ.

Silurus.
——— *Horn Pout.*

ORDER VII.—MALACOPTERYGII—SUBRACHIATI.

Family I.—Gadites.

Gadus.
morrhua. *Common Cod.*
rupestris. *Rock Cod.*
arenosus. *Shoal Cod.*
merluccius. *Hake.*
taucaud. *Tom Cod.*
fuscus. *Frost-fish.*

Brosmus.
vulgaris. *Cusk.*

Morrhua.
æglefinus. *Haddock.*

Merlangus.
vulgaris. *Whiting.*
pollachius. *Pollock.*

Blennius.
viviparus. *Blenny.*
Raniceps.
blenoides. *Garter-fish.*

Family II.—Pleuronectes.

Platessa.
vulgaris. *Flounder.*
——— *Plaise.*
Hypoglossus.
vulgaris. *Holibut.*
Solea.
vulgaris. *Sole.*
Rhombus.
maximus. *Turbot.*

Family III.—Discoboli.

Cyclopteras.
lumpus. *Lumpfish.*
minutus. *Small Lump Sucker.*
Echeneis
remora. *Sucking Fish.*
naucratus. *Indian Remora.*

ORDER VIII.—MALACOPTERYGII—APODES.

Anguilla.
vulgaris. *Common Eel.*
Conger.
muræna. *Conger Eel.*

ORDER IX.—ACANTHOPTERYGII.

Family II.—Goboides.

Anarchicas.
lupus. *Wolf Fish.*

Family III.—Labroides.

Labrus.
tautoga. *Tautog.*
tautoga fusca.
tautoga alia.
coricus. *Blue Perch.*
squeteague. *Squetee.*
maculatus. *Spotted Squetee.*
Crenilabrus.
merula. *Blue Back.*

Family IV.—Percoides.

Scorpæna.
porcus. *Yellow Sculpin.*
scrofa.
gibbosa.
Mugil.
albula. *White Mullet.*
Mullus.
barbatus. *Red Mullet.*
Perca.
fluviatilis. *River Perch.*
labrax. *Striped Basse.*
Bodianus.
leucos. *Silver Perch.*

Bodianus.
rufus. *Red Perch.*
pallidus. *White Perch.*
flavescens. *Yellow Perch.*
Perca.
Uranascopus.
scaber.
Trigla.
palmipes. *Web-fingered Gurnard.*
Cottus.
gobio. *River Bullhead.*
quadricornus. *Sea Bull.*
scorpius. *Sculpin.*
cataphractus. *Armed Bullhead.*
Batrachus.
grunniens. *Grunting Bullhead.*
Lophius.
piscatorius. *Angler.*

Family V.—Scomberoides.

Scomber.
grex. *Chubbed Mackerel.*
vernalis. *Spring Mackerel.*
crysos. *Yellow Mackerel.*
plumbeus. *Horse Mackerel.*
maculatus. *Spanish Mackerel.*
scomber. *Common Mackerel.*
thynnus. *Tunny.*
Centronotus.
ductor. *Pilot Fish.*
Zeus.
faber. *Common Dory.*
Chrysotosus.
luna. *Moon Fish.*
Xiphius.
gladius. *Sword Fish.*

Family VI.—Squamipennes.

Seserinus.
alepidotus.

Family VII.—Fistularidæ.

Fistularia.
tabacaria. *Tobocco pipe Fish.*

V.—TESTACEA OR SHELLS.

List of the Marine Shells of Massachusetts, arranged according to the System of Lamarck.

BY THOMAS A. GREENE, ESQ. OF NEW BEDFORD.

CLASS IX.—ANNELIDES.

ORDER III.—SEDENTARIA.[*]

Pectinaria.
belgica, *Sabella belgica L.*

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[*] It will be seen that no attempt has been made to give in this Report, a catalogue of the two other orders of Annelides in Massachusetts. But few of these animals have attracted the attention of our naturalists, and they are for the most part so out of the reach of common observation as to excite the interest of no one but the zoologist. Dr. Gould has mentioned to me that he has noticed the following species of these animals among us.

Halithea aculeata, Lamk.
Lumbricus terrestris, Lin. *Earth Worm.*
Hirudo—six species. *Leech.*
Gordius aquaticus, L. *Hair Worm.*

E. H.

Terebella.
conchilega, L.
This has been subdivided into several species, two of which have been seen on our shore.

Spirorbis.
nautiloides. *Serpula Spirorbis, L.* On Sea weed

Serpula.
vermicularis.
contortuplicata.

CLASS X.—CIRRHIPEDA.

ORDER I.—SESSILIA.

Balanus.
tintinnabulum. On the bottoms of Ships.
ovularis. *Lepas balanoides, Wood*—on plank, timber, &c.
miser. Very abundant on our rocks.
punctatus, Montague. *Lepas punctata, Wood and Dillwyn*—also on our rocks.
fistulosus.

ORDER II.—PEDUNCULATA.

Anatifa.
lævis. *Lepas anatifera L.* On the bottoms of ships.
vitrea. *Lepas vascicularis.* Found at Nantucket.

Cineras.
vittatus. *Lepas vittata.* On the bottoms of Ships

CLASS XI.—CONCHIFERA.

ORDER I.—BIMUSCULOSA.

Teredo.
navalis. On the bottoms of Ships.

Pholas.
crispata.

Solen.
ensis.
viridis. Not common in the N. England States.

Solecurtus.
Caribæus. Rare, found at New Bedford.
costatus, Say. Common at Nahant Beach.
fragilis. *centralis, Say.* Found at New Bedford.

Mya.
mercenaria, Say. *Common Clam.*

Anatina.
convexa, Turton. Thracia of Blainville.
Leana, Conrad. *prætenuis? Turton.* At Nantucket.

Mactra.
solida.
gigantea, Lam. *Solidissima Dillwyn.*
subtruncata.
lateralis, Say.
subtriangulata. *arctata, Conrad.* Figured in the supplement to Wood's 'Index Testaceologicus.'

Mactra.
tellinoides, Conrad.
Solemya.
velum, Say. Not uncommon at N. Bedford.
Amphidesma.
corbuloides. *Mya Norwegica, Wood and Dillwyn.*
M. hyalina, Conrad.
Corbula.
ferruginosa. *Mya ferruginosa, Wood.* Not described by Lamarck.
Pandora.
trilineata, Say. Found in Nantucket Harbor.
Petricola.
pholadiformis, Lam. *fornicata, Say.* Very common.
Sanguinolaria.
fusca, Conrad. At Nantucket.
Tellina.
polita, Say. Found at N. Bedford.
Lucina.
divaricata. A single valve found at Chatham. *Astarte castanea, Say.*
Ocean shore at Nantucket.
Astarte—a distinct species, with margins entire.
Cyprina.
Islandica. *Venus Islandica, L.* Common in Essex
[County.
Venus.
mercenaria. *Common Quahog or Round Clam.*
præparca, Say.
notata, Say.
Cardium.
Mortoni, Conrad. Very common at New Bedford.
pinnulatum, Conrad.
Cardita.
This species appears to be undescribed.
Arca.
ponderosa, Say. } These were found at Smith's
pexata, Say. } point, on the ocean shore of Nantucket.
transversa, Say. Not uncommon in Buzzard's Bay.
Nucula.
margaritacea. *Nucula proxima, Say. Arca nucleus, L.*
rostrata, Montague. *limatula, Say.*

ORDER II.—UNIMUSCULOSA.

Modiola.
papuana. *Mytilus modiolus., L.*
Mytilus.
edulis.
ungulatus.
pellucidus.
incurvatus.
demissus. Very abundant at New Bedford.

Pecten.

Magellanicus. Rare in Ms. Common at Eastport Me.
Islandicus. *Pealeii, Conrad*, Rare.
concentricus, Say. *Common Scallop.*

Ostrea.

Virginica. *Common Oyster.*

Anomia.

ephippium. Abundant in N.Bedford.
undulata. Is it a distinct species from the preceding?

CLASS XII.—MOLLUSCA.

ORDER II.—GASTEROPODA.

Chiton.

Found at Nantucket. Not described to my knowledge.

Patella.

alveus, Conrad.
amœna, Say.

Crepidula.

fornicata, Say. Very common on our coast.
glauca, Say.
plana, Say. Found in Nantucket Harbor.

ORDER III.—TRACHELIPODA

Velutina.

rupicola, Conrad.

Bulla.

solitaria, Say. Is it a variety of B. hydatis? Found at Holme's Hole.

Natica.

duplicata, Say.
heros, Say.
triseriata, Say. *Nerita intricata* of Wood's Supplement.

Melampus.

videntatus, Say. Common in salt marshes. At New Bedford.

Lacuna.

pertusa, Conrad.

Turbo.

obligatus, Say.
irroratus, Say.
palliatus, Say.

Turritella.

bisuturalis, Say.
alternata, Say.

Fusus

Islandicus. *Murex corneus, Wood and Dillwyn. Fusus corneus, Say.*
cinereus, Say.

Fusus.
decemcostatus, Say. *Murex carinatus, Pennant.*

Ranella.
caudata. At Nantucket.

Pyrula.
canaliculata. *Murex canaliculata.*
carica.

Nassa.
obsoleta, Say. *Buccinum noveboracense, Wood's Supplement.*
trivittata, Say.
lunata, Say.

Purpura.
lapillus. *Buccinum lapillus, L.*
imbricata, Lam.

Buccinum.
undatum, L.

Columbella.
terpsichore. *Buccinum terpsichore, Wood's Supplement.*

ORDER VI.—CEPHALOPODA.

Spirula.
Peronii. *Nautilus spirula, L.* Found on the ocean shore of Nantucket.

List of Land and Fresh Water Shells in Massachusetts, so far as they have been ascertained.

BY MR. JOHN MILTON EARLE, OF WORCESTER.

I.—BIVALVES.

Unio.
complanatus, Lam. *purpureus, Say.*
nasutus, Say. Ponds in Essex and Plymouth Counties.
ochraceus, Say. Ponds in Plymouth County.
radiatus, Say. Do. and Essex Counties.

Alasmodonta.
margaritifera, L. *arcuata, Barnes.*
marginata, Say. Blackstone River.
undulata, Say. Do. and streams in Plym. County.

Anadonta.
cataracta, Say. Common Green Muscle.
marginata, Say. Blackstone and French Rivers.
lugubris, Say. Ponds in Essex County.

Cyclas.
similis, Say.

Cyclas.
dubia,* Say.
And two species not described.

II.—UNIVALVES.

Paludina.
decisa, Say.
limosa ? Say.

Planorbis,
trivolvis, Say.
bicarinatus, Say.
armigerus, Say.
campanulatus.
parvus, Say.

Lymnæa.
catascopium, Say.
heterostropha, Say.
columella, Say.
And one species not ascertained.

Valvata.
arenifera ? Lea.

LAND SHELLS.

Helix.
albolabris. *Common Wood Snail.*
arboreus, Say.
tridentata, Say.
alternata, Say.
glaphyra, Say.
thyroidus, Say.
minuta, Say.
hirsuta, Say.
labyrinthica, Say,
perspectiva, Say.
fraterna, Say. and two other species.

AMPHIBIOUS.

Succinea
ovalis, Say.
campestris ? Say.
and one species not ascertained.

Pupa.
corticaria ? Say.

Caracolla.
one species not ascertained.

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* This does not agree exactly with my specimens of the dubia found in Pennsylvania, but I think it not sufficiently distinct to be separated from that species.

In the first edition of this Report, there followed in this place a *List of shells observed on and near the coast of New England*, by Col. Joseph G. Totten, containing about 125 species. But the Boston Society of Natural History have recently prepared with much care a catalogue of all the shells ascertained to exist within the limits of Massachusetts up to the present time (Oct. 1834,) and embracing nearly all the species in Col. Totten's Catalogue. I could not doubt, therefore, but the intention of the Government would be more perfectly answered by substituting the list prepared by the Society for that of Col. Totten, since both could not be inserted. I do not mean thereby to intimate the inferiority of his Catalogue; but merely that it is not so well adapted to the particular object of the Government because it is not limited to Massachusetts. The new species ascertained by the Society might have been added to Mr. Greene's Catalogue, had there been time after their receipt to have consulted that gentleman and the Society as to certain supposed synonymes, concerning which I did not feel competent to decide. Amos Binney Esq. chairman of the Society's Committee, who forwarded the following list, observes that 'it is far from being complete, particularly in those species destitute of shells, many of which exist in our waters undescribed, or if described, not known to us.' He observes also, that 'in sending this list we do not intend to be understood as guaranteeing the correctness of the species, but simply that the species so named by the authors whose names are attached, are found in the waters of our State.'

A CATALOGUE OF SPECIES,

Beginning with the third Order of Lamarck's Class Annelides, and continuing through the 10th, 11th, and 12th Classes.

CLASS IX.—ANNELIDES. LAM.

ORDER III.—SEDENTARIA.

Pectinaria.
    Belgica, Lam.
Terebella.
    conchilega, Lam.
Spirorbis.
    nautiloides, Lam.
Serpula.
    vermicularis, Lin.
    contortuplicata, Lin.
    echinata, Gmel.

CLASS X.—CIRRHIPEDA. LAM.

ORDER I.—SESSILIA.

Balanus.
    tintinabulum, Lam.
    punctatus, Brug.
    miser, Lam.
    ovularis, Lam.
    fistulosus, Brug.
    geniculatus, Conrad.
        one or more other species.

ORDER II.—PEDUNCULATA.

Anatifa.
    lævis, Lam.
    vitrea, Lam.
    dentata, Brug.
    sulcata, Montague.
Cineras.
    vittata, Leach.
Otion.
    Cuvieri, Leach.
Teredo.
    navalis, Lin.
Pholas.
    crispata, Lin.

CLASS XI.—CONCHIFERA. LAM.

ORDER I.—BIMUSCULOSA.

Solen.
ensis, Lin.
viridis, Say.

Solecurtus.
Caribæus, Blain.
maximus,
costatus, Say.
fragilis, Pulteney.

Glycimeris.
siliqua, Lam.

Mya.
mercenaria, Lin.

Anatina.
Leana, Conrad.
convexa,

Mactra.
gigantea, Lam.
lateralis, Say.
arctata, Conrad.
tellinoides, Conrad.

Solemya.
velum, Say.
borealis, Totten.

Amphidesma.
corbuloides, Lam.

Corbula.
ferruginosa, Wood.
contracta, Say.

Pandora.
trilineata, Say.

Saxicava.
distorta, Say.

Petricola.
pholadiformis, Lam.
dactylus, Say.

Sanguinolaria.
fusca, Conrad.

Tellina.
polita, Say.

Lucina.
divaricata, Lam.

Astarte.
castanea, Say.

Cyclas.
similis, Say.
dubia, Say.

Cyprina.
Islandica, Lam.

Cytherea.
convexa, Say.

Venus.
mercenaria, Lin.
præparca, Say.

Venus.
notata, Say.
gemma, Totten.

Cardium.
- Mortoni, Conrad.
- pinnulatum, Con.

Cardita.
- borealis, Conrad.

Arca.
- ponderosa, Say.
- pexata, Say.
- transversa, Say.

Nucula.
- margaritacea, Lam.
- rostrata, Montague.

Unio.
- complanatus, Soland.
- nasutus, Say.
- ochraceus, Say.
- radiatus, Lea.

Alasmodonta.
- arcuata, Barnes.
- marginata, Say.
- undulata, Say.

Anodonta.
- cataracta, Say.
- marginata, Say.
- lugubris, Say.

ORDER II.—UNIMUSCULOSA.

Modiola.
- papuana, Lam.
- plicatula, Lam.
- glandula, Totten.

Mytilus.
- edulis, Lin.
- ungulatus, Humboldt.
- incurvatus, Maton.
- pellucidus,

Pecten.
- Magellanicus, Lam.
- Islandicus, Lam.
- concentricus, Say.

Ostrea.
- Canadensis, Lam.
- Virginica, Lam.
- edulis, Lin. Var.

Anomia.
- ephippium, Lin.

Terebratula.
- an undescribed recent species.

CLASS XII.—MOLLUSCA.

ORDER II.—GASTEROPODA.

Chiton.
- one species.

Patella.
- alveus, Conrad.
- amœna, Say.

Crepidula.
- fornicata, Say.
- glauca, Say.

Crepidula.
- plana, Say.
- convexa, Say.

Ancylus.
- rivularis, Say.

Velutina
- rupicola, Conrad.

Bulla.
- solitaria, Say.

Limax.
- one or more species.

Testacella.
- one or more species.

ORDER III.—TRACHELIPODA.

Helix.
- albolabris, Say.
- thyroidus, Say.
- alternata, Say.
- perspectiva, Say.
- glaphyra, Say.
- arborea, Say.
- tridentata, Say.
- hirsuta, Say.
- fraterna, Say.
- labyrinthica, Say.
- minuta, Say.
- subglobosa,(manuscript.)

Pupa.
- fallax, Say.
- corticaria, Say.

Succinea.
- ovalis, Say.
- campestris, Say.

Auricula.
- myosotis, Drap.

Planorbis.
- trivolvis, Say.
- bicarinatus, Say.
- armigerus, Say.
- campanulatus, Say.
- parvus, Say.
- two or more other species.

Physa.
- heterostropha, Say.

Lymnœa.
- catascopium, Say.
- columella, say.
- ovata, Lam.
- two or more other species.

Valvata.
- arenifera, Lea.

Paludina.
- decisa, Say.
- limosa, Say.
- lapidaria, Say.
- one other species.

Natica.
- duplicata, Say.
- heros, Say.
- triseriata, Say.

Melampus.
    bidentalis, Say.
Vermetus.
    lumbricalis, Lam.
Lacuna.
    pertusa, Conrad.
    fusca, (manuscript.)
Turbo.
    obligatus, Say.
    palliatus, Say.
    vestita, Say.
    irroratus, Say.
    inflatus, Totten.
    minutus, Totten.
Turritella.
    alternata, Say.
    bisuturalis, Say.
Fusus.
    corneus, Say.
    cinereus, Say.
    decemcostatus, Say.
Pyrula.
    caniculata, Lam.
    carica, Lam.
Ranella.
    caudata, Say.
Purpura.
    lapillus, Lam.
    imbricata, Lam.
Buccinum.
    undatum, Lin.
Nassa.
    obsoleta, Say.
    trivittata, Say.
    lunata, Say.
    vibex, Say.
Columbella.
    avara, Say.

ORDER IV.—CEPHALOPODA.

Spirula.
    Peronii, Lam.
Loligo.
    illecebrosa, Lesueur.
    pavo, Lesueur.
    one or more other species.

VI.—CRUSTACEA.

BY AUGUSTUS A. GOULD, M. D. OF BOSTON.

ORDER I.—DECAPODA.

Family I.—Brachyura.

Portunus.
    pictus, Say. *P. lividus, Leach. Cancer depurator, Oliv. Sand Crab.*
Lupa.
    hastata, Fab. *Edible Crab.*

Cancer.
granulatus, S. *C. Mænas, L.*
irroratus, S.
undecimdentatus? F.
Panope, S.
Ocypode.
pugilator, S. *Fiddler Crab.*
Pinnotheres.
ostreum, S. In Oysters.
Pilumnus.
one species. Marshes, Cambridge.
Grapsus.
pelagicus, S. On sea weed, Gulf stream.
Libinia.
canaliculata, S. *Spider Crab.*

Family II.—Macroura.

Astacus.
marinus, F. *Common Lobster.*
Bartonii, Bosc. *Craw-Fish. Fresh Water Lobster.*

Crangon.
septemspinosus, S. *Shrimp.*
Palæmon.
vulgaris, S. *Prawn or Shrimp.*
Pagurus.
Bernhardus, Lin. in Buccinum undatum and Natica.
pollicaris, S. in Natica and Pyrula &c. } *Hermit Crabs.*
longicarpus, S. in Nassa, Columbella, &c.
Hippa.
emerita? F. *talpoida? S. Sand Bug.*

ORDER II.—STOMAPODA.

Squilla.
empusa, S.

ORDER III.—AMPHIPODA.

Gammarus.
fasciatus, S. *G. Marinus? Leach.* } *Beach Fleas.*
minus, S.
Talitrus.
longicornis, S. } *Beach Fleas.*
gryllus, Bosc.

ORDER IV.—LÆMODIPODA.

Cyamus.
ceti, L. *Whale Louse.*

ORDER V.—ISOPODA.

Cymothoa.
ovalis, S. *Æga emarginata, Leach.*
impressa, S. *Æga bicarinata, Leach.*
Idotæa.
cæca, S.
tricuspidata? Leach:
and one other.
Stenosoma.
irrorata, S.
Asellus.
communis, S.
and one more.
Ligia.
oceanica, Desm. *Oniscus oceanicus, L.*

Oniscus.
  asellus, L. *O. affinis, S. Wood Louse.*

Armadillo.
  vulgaris, Latr. *A. pilularis, S.*

ORDER VI.—BRANCHIOPODA.

Branchipus.
  one or more species.

ORDER VII.—PŒCILOPODA.

Limulus.
  polyphemus, L. *Horse-shoe. King-crab.*

The preceding Catalogue of the Crustacea differs materially from that in the first edition. Besides being somewhat enlarged, more extended observations and investigations have enabled us to make several corrections, and to offer, with more confidence of its accuracy, the whole list. It still remains far from complete, especially as regards the smaller individuals. We have been obliged to rely chiefly on Mr. Say's papers in the Journal of the Academy of Natural Sciences for descriptions; and although we have adopted his names, we are not satisfied that he has always referred his species to the right genera, whether of Leach or Desmarest, the two greatest authorities in Crustacealogy. The objects we have examined differ in general from his descriptions by being of a much larger size. We have also added synonyms in a few instances, believing that those Crustacea, described by Mr. Say as new, are either identical with, or very closely allied to European species already described.

All the species enumerated are in the Cabinet of the Boston Society of Natural History.

VII.—ARANEIDES. *Latr.*

THE SPIDERS.

BY PROFESSOR N. M HENTZ.

The following catalogue embraces a wider field than Massachusetts. The species, indeed, have been obtained from various parts of the United States. This arose from a misapprehension on the part of Professor Hentz of the precise object I had in view. Yet I did not think it important enough to request him to alter the list. The interesting notes which accompanied this catalogue, being too extended for this place, were forwarded to the editor of the American Journal of Science, and published in the 21st volume of that work. The whole paper forms, indeed, a valuable monagraph of the Spiders of the United States.

Oletera.
  Carolinensis.
  nigra.

Filistata ?
  hibernalis.

Dysdera.
  teterrima.

Segestria ?
  pumila.

Herpyllus.
  ecclesiasticus.
  ater.
  cruciger.
  ornatus.
  bilineatus.
  bicolor.
  descriptus.
  variegatus.

Clubiona.
- tranquilla.
- gracilis.
- pallens.
- celer.
- obesa.
- inclusa.

Tegeneria.
- punctata.
- medicinalis, Hentz. (Journ. Acad. Nat. Sciences. II, 53.)

Agelena.
- nævia ? Bosc.
- plumbea.

Theridium.
- verecundum.
- lineatum.

Theridium.
- vulgare.
- boreale.
- and another species.

Pholcus.
- Atlanticus.

Lyniphia.
- communis.
- pumila.
- autumnalis.
- coccinea.
- and one doubtful species.

Tetragnatha.
- laboriosa.
- ferox.

Epeira, L.
- riparia.
- Latreillana.
- obesa.
- Pennsylvanica.
- vulgaris.
- trefolium.
- infumata.
- septima.
- prompta.
- hortorum.
- pratensis.
- cancer.
- caudata.
- militaris ?
- verrucosa.
- alba.
- rugosa
- spinea.
- labyrinthea.
- and seven species not named.

Mimetus.
- syllepsicus.

Thomisus.
- fartus.
- piger.
- celer.
- vulgaris.
- parvulus.
- Carolinensis.
- ferox.
- and another species.

Sphasus.
- nitidans.
- salticus.
- scalaris.

Dolomedes.
- tenebrosus.
- tenax.
- sexpunctatus.
- lanceolatus.
- and two more species.

Lycosa.*
- tarantula Carolinensis ?

Lycosa.
- lenta.
- parva.
- ocreata.
- littoralis.
- punctulata.
- fatifera.
- maritima.
- and three other species.

Attus.
- familiaris.
- superciliosus.
- insolens.
- rarus.
- viridis.
- parvus.
- niger.
- castaneus.
- coccineus.
- elegans.
- sexpunctatus.
- tripunctatus.
- militaris.
- vittatus.
- grandis.
- cyaneus.
- audax.
- rufus.
- Nuttallii.
- sylvanus.
- auratus.
- and eight more species.

Epiblemum.
- faustum.
- palmarum.

Synemosyna.
- formica.
- and two more species.

The number of 125 species will appear very large, but I could have swelled the list to 150. Spiders differ from true insects, or at least *winged* insects, in their *growing*. They come out from their eggs very minute, and continue to increase in size, probably for several years in many species; whereas, with few exceptions, insects come out of their *pupa* state, at once, with the size, which is peculiar to them. The ARANEIDES, in their different ages, present differences of color and marking. The *seasons* also produce a change in the colors of some spiders; and, I am nearly convinced that the first frosts produce a total change in the dress of several described EPEIRÆ, which may be refered to one name. These are the considerations which have induced me to be very cautious in adopting new species, and comparing many specimens in different seasons, when possible, before I described them.

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* The famous Tarantula of the South of Europe, the bite of which, for many years, was supposed to produce a disease that music alone could cure, belongs to this genus: and I found on Round Hill (Mass) a species (*Lycosa fatifera*, of my catalogue) which is probably very closely related to the European species, and which dwells in holes, nearly a foot deep.

VIII.—INSECTS.

BY THADDEUS WILLIAM HARRIS, M. D.

I.—COLEOPTERA.

CICINDELIADÆ.

Cicindela.
- generosa, Dejean.
- vulgaris, Say.
- patruela, D.
- purpurea, Olivier. marginalis, Fabricius.
- sexguttata, F.
- rugifrons, D. C. unicolor, D. is merely a variety.
- marginata, F. variegata, D.
- dorsalis, S.
- hirticollis, S. albohirta, D.
- repanda, D. hirticollis, var. S.
- duodecimguttata, D. hirticollis, var. S.
- hæmorrhoidalis, Hentz.
- punctulata, O.

CARABIDÆ.

Casnonia, Latreille.
- Pennsylvanica, L.

Galerita, F.
- Americana, L,

Brachinus, Weber.
- librator ? D.
- fumans, L.
- formosus.
- perplexus ? D.
- cordicollis, D.
- cyanipennis, S.
- medius, Harris.
- minutus, H.

Helluo, Bonelli.
- præustus, D.

Plochionus, D.
- Bonfilsii ? D.

Cymindis, Latr.
- pilosus, S.
- platicollis, S.
- comma.
- glabratus.
- biplagiatus.

Dromius ? Bon.
- subsulcatus ? D.

Calleida, D.
- smaragdina, D.

Lebia, Latr.
- grandis, Hentz.
- tricolor, S.
- borea, Hentz.
- atriventris, S.
- pulchella, D.
- vittata, F.
- solea, Hentz.
- ornata, S.
- decora, S.
- viridis, S.

Scarites, F.
- subterraneus, F.

Clivina, Latr.
- lineolata, S.
- globulosa, S.

Cychrus, F.
- viduus, D.

Cychrus (Sphæroderus, D.)
- stenostomus, Weber.

Cychrus (Scaphinotus, D.)
- elevatus, F.

Carabus, L.
- vinctus, Weber. interruptus, S.
- sylvosus, S.
- limbatus, S.
- serratus, S.

Calosoma, Weber.
- scrutator, F.
- calidum, F.
- obsoletum, S.

Nebria, Latr.
- pallipes, S.

Omophron, Latr.
- labiatum, F.

Elaphrus, F.
- fuliginosus, S.
- ruscarius, S. formerly riparius, S.

Nothiophilus, Dumeril.
- semistriatus, S.
- porrectus, S.

Oodes, Bon.
- Americanus, D.
- amaroides, D.

Chlænius, Bon.
- prasinus, D.
- rufipes, D.
- sericeus, Forster.
- tomentosus, S.
- nemoralis, S.
- pubescens, H.
- lithophilus, S.
- distans. niger.
- purpuricollis.
- emarginatus, S.

Rembus, Latr.
- impressicollis ? D.

Dicælus, Bon.
- dilatatus, S.
- elongatus, Bon. furvus, D.
- politus, D. Leonardii, H.

Panagæus, Latr.
- fasciatus, S.

Patrobus, Megerle.
- longicornis, S. Americanus, D.

Calathus, Bon.
- gregarius, S. piceus, H.

Pristodactyla, D.
- Americana, D.

Platynus, Bon.
- pusillus.

Anchomenus, Bon.
  extensicollis, S.
  decorus, S.
  placidus. elongatus.
  maculifrons, S.
Agonum. Bon.
  octopnctatum, F.
  cupripenne, S.
  morosum, D.
  scutellare, S.
  nitidulum ? D. quadrinotatum.
  melanarium, D. collare ? S.
  lenum, D.
  obsoletum, S. luctuosum, D.
  bimarginatum.
  foveolatum.
Feronia, Latr. (Pœcilus, Bon.)
  chalcites, S.
  lucublanda, S.
  fraterna ? S.
Feronia, (Argutor, Megerle.)
  erythropus, D.
  diligens. nitidus.
Feronia (Omaseus, Ziegler.)
  stygica, S. bisigillata, H.
  subpunctata, H. corvina, D.
  polita, H. morosa ? D. muta ? S.
  caudicalis, S.
  hamata, H. luctuosa ? D.
Feronia (Pterostichus, Bon.)
  adoxa, S.
  humida, S.
Myas, Ziegler.
  cyanescens, D. coracinus? S.
Amara, Bon. (Leirus, Megerle.)
  exarata, D.
  confinis, D.
Amara (proper.)
  obesa, S.
  impunctata, S.
  impuncticollis, S.
  angustata ? S.
  basillaris ? S.
  planicosta.
  pusilla.
  undulata.
Daptus, Fischer.
  incrassatus, D.
Agonoderus, D.
  lineola, F.
  pallipes, F.
Harpalus, Latr. (Pangus, Ziegler.)
  caliginosus, F.
Harpalus (Anisodactylus, D.)
  agricolus, S.
  discoideus, D.
  Baltimoriensis, S.
  rusticus, S.
  merula, D.
Harpalus (Ophonus, Ziegler.)
  sericeus, H. femoratus, D.

- Harpalus (proper)
  - erraticus, S.
  - viridis, S.
  - bicolor, F.
  - faunus, S.
  - herbivagus, S.
  - spadiceus, D.
  - vulpeculus, S. nigripennis, D.
  - terminatus, S.
  - merula.
  - pallidus.
  - interstitialis, S. obscuripennis, D.
  - hylacis, S.
- Stenolophus, Megerle.
  - ochropezus, S.
  - fuliginosus, D.
- Acupalpus, Latr.
  - cinctus, S. elongatulus, D.
  - partiarius, S. pauperculus ? D.
  - conjunctus, S. misellus, D.
- Bembidium, Latr.
  - tetracolum, S.
  - oppositum, S.
  - contractum, S.
  - cognatum, D.
  - variegatum, S.
  - flavicaudum, S.
  - delum.
  - inornatum, S.

DYTICIDÆ.

- Dyticus, Geoffroy.
  - verticalis, S.
  - Carolinus.
  - fasciventris, S.
- Dyticus (Acilius, Leach.)
  - fraternus, H.
  - mediatus, S.
  - basillaris, H.
- Dyticus (Hydaticus, Leach.)
  - fasciaticollis, H.
  - liberus S.
  - apicialis.
- Colymbetes, Clairville.
  - sculptilis, H.
  - fimbriolatus.
  - binotatus, H.
  - suturellus, H.
  - fenestralis, S.
  - bicarinatus, S.
  - erytropterus, S. discolor, H.
  - seriatus, S.
  - obtusatus ? S.
  - tæniolatus, H.
  - venustus, S.
  - acuductus, H.
- Laccophilus, Leach.
  - maculosus, S.
- Hydroporus, Clairville.
  - niger, S.
  - catascopium, S.

- **Hydroporus**, Clairville.
  - fasciatus, H. oppositus ? S.
  - rectus.
  - affinis, S.
- **Hyphydrus**, Latr.
  - punctatus, H.
  - notatus.
- **Haliplus**, Latr.
  - duodecimpunctatus, S:
  - immaculaticollis, H.

GYRINIADÆ.

- **Gyrinus**, L.
  - emarginatus, S.
  - Americanus, L.
  - labratus.
  - limbatus, S.
  - analis, S.
  - arctus.

STAPHYLINIADÆ.

- **Oxyporus**, F.
  - emarginatus.
  - femoralis, Gravenhorst.
- **Staphylinus**, L.
  - villosus, G.
  - immaculatus.
  - maculosus, G.
  - cingulatus, G.
  - fossator, G.
  - prælongus. ater ? G.
  - cinnamopterus, G.
  - cyanipennis, F.
  - nigripes.
  - pallipennis.
  - violaceus, G.
  - anthrax, G.
  - bratilis.
  - interpunctatus.
  - tepidus.
- **Xantholinus**, Dahl.
  - cephalus, S.
- **Lathrobium**, G,
  - cinctum ? S.
  - rotundicolle.
- **Pæderus**, F.
  - littorarius, G.
  - discopunctatus, S.
- **Rugilus**, Leach.
  - dentatus, S.
  - confluentus, S.
- **Stenus**, Latr.
  - geniculatus, S.
  - femoratus ? S.
- **Omalium**, G.
  - rotundicolle, S.
- **Aleochara**, G.
  - lata, G.
  - verna, S.
- **Tachinus**, G.
  - fimbriatus, G.
  - memnonius, G.

Tachinus, G.
cincticollis, S.
obsoletus, S.
Tachyporus, G.
discoidalis.
fumipennis, S.
unicolor.
jocosus, S.

PSELAPHIDÆ.

Pselaphus, Herbst.
carinatus, S.
corrugatus.

BUPRESTIADÆ.

Buprestis L.
Geranii, H. tubulus? F.
Virginica, Drury.
striata, F.
maculiventris, S.
longipes, S.
divaricata, S.
tuberculata.
sylvatica. nubila.
obscura? F.
lurida? F.
fasciata, O.
coronata.
lineata, F.
plagiata.
fulvoguttata, H.
characteristica, H. dentipes? Germar.
femorata, F.
fastigiata.
strangulata.
sexguttata, S.
Harrisii, Hentz.
cogitans, Weber. ignara? F. innuba? F.
viridicornis, S.
Bupestris (Agrilus, Megerle.)
ignara? F. paganica.
polita, S.
ruficollis? F. geminata? S.
otiosa, S.
Trachys, F.
tessellata, F.
ovata, Weber.
Trachys (Metonius, Say.)
lævigata, S. ovatus, S.
Aphanisticus, Latr.
gracilis, S.
Melasis, Olivier.
semivittatus.

ELATERIADÆ.

Eucnemis, Ahrens.
longulus. amœnicornis.
clypeatus. Elater clypeatus? S.
Elater, L. (Tapheicerus.)
obtectus.
foveolatus. operculatus.
auroratus.
pennatus, F.

Elater (proper.)

oculatus, L.
myops, F.
discalceatus.
longicornis.
brevicornis, S.
abruptus, S.
attenuatus, S.
carbonarius.
auriculatus.
elongatus ? Palisot de Beauvois. pyrros ? Herbst.
bilobatus.
cucullatus, S.
canaliculatus.
silaceus, S.
vespertinus, F.
viridanus, S.
inquinatus.
spiraculatus.
cylindriformis, S.
plebejus, S.
agonus.
mancus, S.
appressifrons, [illegible]
decoloratus,
xanthopus.
scapularis.
apicatus.
quercinus, S,
cruciatus, L.
hieroglyphicus.
lugubris ? Pal. de Beauvois.
discoideus, F.
hamatus.
oblessus, S.
contemptus. erytropus.
metallicus.
glaber.
collaris, S.
vernalis, Hentz.
inflatus, S.
convexulus.
pumilus. obesus ? var. S.
plagicollis.
sanguinipennis, S.
dorsalis, S.
dilectus, S.
stigma, Herbst.
cardisce:
bigeminatus.
pectoralis.
silaceipes. abbreviatus ? var. S.
atriventris:

Elater (Campylus, Fischer.)

septentrionalis.
exiguus.

Elater (Nothora.)

cinereus, Weber.
corticinus, S. dispar ? Herbst.
communis, S. chönherr. S.
bicolor.
pertinax.
tenax.

Elater (Lissomus, Dalman. Drapetes, Megerle.)
Americanus. rufinotatus.

CEBRIONIADÆ.

Anelastes? Kirby.
sericea.
Physodactylus? Fischer.
cisteloides.
Sandalus? Knoch.
lineatopunctatus.
Ptylodactyla, Illiger.
discoida, S. (Cyphon.)
Dascillus, Latr.
two species.
Elodes, Latr.
ovalis, S.
bicolor.
Scirtes, Latr.
tibialis.
orbiculatus, F.

LAMPYRIDIDÆ.

Lycus, F.
Smithii.
reticulatus, F.
terminalis, S.
perfacetus, S. marginellus? F.
Omalisus, Geoffroy.
coccinatus.
humeralis? F. scapularis.
crenatus? Germar.
quadricollis.
marginellus.
Phengodes, Hoffmansegg.
plumosa, O.
Lampyris, L.
versicolor, F.
centrata, S.
angulata, S.
scintillans, S.
corrusca, L.
laticornis, F.
decipiens. nigricans? S.
Telephorus, Schæffer.
rotundicollis, S.
Carolina, F.
basillaris, S.
diadema, F.
bilineatus, S.
rufipes, S.
scitula, S.
tricostatus.
constrictus.
laticornis, S.
lacrymosus.
percomis.
Telephorus (Chauliognathus, Hentz.)
marginatus, F.

MELYRIDIDÆ.

- **Malachius, F.**
  - vittatus, S.
  - quadrimaculatus, F.
  - tricolor, S.
  - circumscriptus ? S.
- **Dasytes, Paykull.**
  - terminalis. Malachius terminalis ? S.

PTINIDÆ.

- **Ptinus, L.**
  - fur, L.
- **Ptilinus, Geoffroy.**
  - ruficornis, S.
- **Dorcatoma, Herbst.**
  - oculata, S.
- **Xyletinus, Latr.**
  - thoracicus.
  - sericeus, S.
  - punctipennis.
- **Anobium, F.**
  - gibbosum, S.
  - tessellatum ? F.
  - carinatum, S.
  - molle ? F.
  - pertinax ? F.
  - notatum, S.
  - tenuestriatum, S.
  - bistriatum, S.
  - paniceum, F.

LYMEXYLIDÆ.

- **Cupes, F.**
  - variegata.
  - capitata, F.

TILLIADÆ.

- **Enoplium, Latr.**
  - pilosum, Forster.
  - onustum, S.

CLERIADÆ.

- **Thanasimus, Latr.**
  - dubius, F.
  - undulatus.
  - nigrifrons, S.
  - unifasciatus ? S, analis.
  - thoracicus, O.
  - coccineus. Not strictly a Thanasimus.
  - oculatus.
  - dislocatus ? S. (Enoplium.) Not strictly Thanasimus
  - pallipennis. S. } Allied species, not strictly belonging to this genus.
  - humeralis, S.
  - verticalis.
- **Clerus. Geoffroy.**
  - Nuttalii, Kirby.
- **Necrobia, Latr.**
  - violacea, L.
  - ruficollis, F.
  - rufipes, F.

HISTERIADÆ.

- Hister, L.
  - arcuatus, S.
  - cadaverinus, Paykull. interruptus ? Pal. de Beauvois.
  - merdarius, F.
  - unicolor ? L. anhelus.
  - abbreviatus, F.
  - demistriatus.
  - sedecimstriatus, S.
  - fraternus, S.
  - dimidiatus ? P.
  - dimidiatipennis.
  - postjuntcus.
  - Pennsylvanicus, P.
  - pygmæus, Pal. de Beauvois.
  - repletus.
  - duodecimlineatus. pulicarius.
  - indistinctus ? S.
  - assimilis, P. mancus ? S.
  - punctulatus, S.
  - elongatus, O.
- Hister (Platysoma, Leach.)
  - deplanata, Gyllenhal. sordida ? S.
- Hister (Hololepta, Paykull.)
  - tridentata.

SILPHIADÆ.

- Necrophorus, F.
  - Americanus, O. grandis, F.
  - orbicollis, S.
  - marginatus, F.
  - mediatus, F.
  - tomentosus, Weber. velutinus, F.
  - mortuorum, F.
- Necrodes, Leach.
  - Surinamensis, F.
- Silpha, L.
  - Americana, L.
  - marginalis, F.
  - inequalis, F.
  - caudata, S.

NITIDULADÆ.

- Peltis ? F.
  - sulcata.
- Thymalus, Latr.
  - marginatus.
- Nitidula, F.
  - grossa, F.
  - bipustulata, L.
  - undulata, S.
  - variegata, O. colon ? L.
  - sexmaculata, S.
  - mera.
  - adusta.
  - geminata, S.
  - octomaculata, S.
- Cercus, Latr.
  - unicolor, S.
  - viridans.
  - opacus.

Ips, F.
obtusa.
fasciata, O.
dilecta.
immaculata.
sanguinolenta, O.
transversa.
pallitarsa.
octomaculata.
auripilis. Not strictly an Ips.
Dacne, Latr.
fasciata, F.
Byturus, Latr.
unicolor, S.
Cryptophagus, Herbst.
cellaris, O.
Scaphidium, O.
quadripustulatum, S.
unicolor.

DERMESTIADÆ.

Dermestes, L.
vulpinus, F.
lardarius, L.
marmoratus, S.
variegatus, S.
Megatoma, Herbst.
pellio, L.
macellarius, F. and (Dermestes) megatoma, F.
ornata, S.

BYRRHIADÆ.

Anthrenus, Geoffroy.
museorum ? L. varius ? F. trifasciatus.
niger.
Byrrhus, L.
Americanus.
alternatus, S.
obscurus.

PARNIADÆ.

Heterocerus, F.
maculatus.
Dryops, O.
fastigiatus, S.
Elmis, Latr.
Peckii.
Machonychus, Müller.
glabratus, S.

HYDROPHILIDÆ.

Hydrophilus, L.
triangularis, S.
obtusatus, S.
glaber, Herbst.
nimbatus, S.
globosus, S.
ovalis.
rotundus, S.
cinctus, S.
striatus, S. undatus ? F: peregrinus ? Herbst.
nebulosus, S.
subcupreus, S.
fuscus.

- **Elophorus, F.**
  - lineatus, S.
  - alternatus.
- **Hydrochus, Germar.**
  - one species.
- **Hydrobius ? Leach.**
  - obsoletus.
- **Spercheus ? F.**
  - one species.

SPHÆRIDIIDÆ.

- **Sphæridium, F.**
  - occallatum, S.
  - rufum.
  - nigricolle, S.
  - indistinctum.

SCARABÆIADÆ.

- **Atauchus, Weber.**
  - lævis, Drury. volvens, F.
  - nigricornis, S.
- **Onitis, F.**
  - sulcatus, Drury. Nicanor, F.
- **Onthophagus, Latr.**
  - Hecate, Panzer. latebrosus, F.
  - albicornis ? Pal. de Beauv. striatulus ? Pal. de Beauv.
  - subæneus, Pal. de Beauvois. ovatus ? L.
  - bidentatus.
- **Phanæus, Macleay.**
  - carnifex, L.
- **Copris, Geoffroy.**
  - anaglypticus, S.
  - minutus, Drury. Ammon, F.
- **Aphodius, Illiger.**
  - oblongus, S.
  - obliquatus.
  - femoralis ? S. fimosus.
  - vittatus, S.
  - bicolor, S.
  - strigatus, S.
  - terminalis, S.
  - rubeolus, Pal. de Beauvois.
- **Geotrupes, Latr.**
  - exaratus. splendidus ? F.
  - dilatatus. Blackburni ? F.
  - excrementi, S.
  - cupreus.
  - splendidus ? F. Blackburni ? Pal. de Beauvois.
- **Odontæus, Ziegler.**
  - Lazarus, F.
  - filicornis, S.
- **Trox, F.**
  - porcatus, S.
  - capillaris ? S: canaliculatus ? S. echinatus.
  - serrulatus ? Pal. de Beauv. hispidus. variolatus.
  - terrestris, S.
- **Scarabæus, L: Latr.**
  - Jamaicensis, Drury. Satyrus, F.
  - Maimon, F. Antæus ? Drury.

- Scarabæus, L. Latr.
  - relictus, S.
  - geminatus ? F. lugubris ? Schönherr. novator.
  - tridentatus, S.
  - gibbosus, De Geer.
  - vespertinus.
- Rutela, Latr. (Pelidnota, Macleay.)
  - punctata, L.
  - lanigera, L.
- Melolontha F. (Anomala, Megerle.)
  - arboricola, F.
  - luciola, F. cœlebs. The atrata, F. is a variety.
- Melolontha (proper.)
  - occidentalis, L. variolosa, Hentz:
- Melolontha (Rhisotrogus, Latr.)
  - Quercina, Knoch. fervens ? Gyllenhal
  - porcina, Hentz.
  - Georgicana, Gyllenhal.
  - hirticula, Knoch.
  - hirsuta, Knoch.
  - balia, S.
  - fraterna.
  - pilosicollis, Knoch.
  - longitarsa, S.
  - mœsta, S. } not strictly Rhisotrogus.
  - sordida, S.
- Melolontha (Serica, Macleay.)
  - vespertina, Gyllenhal.
  - sericea, S. sericea ? Illiger.
  - iricolor, S.
  - nigricornis.
- Melolontha (Dichelonyx.)
  - hexagona, Germar.
  - linearis, Gyllenhal. elongatula ? F.
- Melolontha (Macrodactyla, Latr.)
  - subspinosa, F.
- Hoplia, Illiger.
  - trifasciata, S.
  - oblonga. maura.
- Amphicoma, Latr.
  - vulpina, Hentz.
- Trichius, F.
  - eremicola, Knoch.
  - scaber, Pal.de Beauv.
  - dispar.
  - maculosus, Knoch.
  - piger, F.
  - lunulatus, F.
- Cremastocheilus, Knoch.
  - Hentzii, H. the canaliculatus, Kirby is a variety.
  - Harrisii, Kirby. Castaneæ ? H.
  - Sayii, H.
- Cetonia, F.
  - fulgida, F.
  - Inda, L. barbata, S.
- Cetonia (Gymnetis, Macleay.)
  - nitida, L.

LUCANIADÆ.

- Lucanus, L.
  - Capreolus, L. Dama, F.
  - latifrons.
  - parallelus, S. Voeti? Schönherr.
- Platycerus, Latr.
  - piceus, Weber.
  - securidens, S.
- Passalus, F.
  - cornutus, F

BLAPTIADÆ.

- Scotinus? Kirby. (Bolitobius.)
  - inequalis. montanus.
- Dendarus, Megerle (Heliophilus ? D.)
  - rorulentus. Pedinus suturalis? S.
  - interruptus. S. Opatrum interruptum, S.

TENEBRIONIADÆ.

- Upis, F.
  - variolosus? Pal. de Beauv. rugosus.
  - clavipes.
  - Pensylvanicus, De Geer. lævis, O.
  - reticulatus, S.
  - saperdoides, O. (Helops spinipes, F. Tenebrio anthracinus, Knoch.)
  - rufipes, S.
  - femorata, F, fulvipes, Herbst.
- Tenebrio, L.
  - granarius. molitor? L. var.
  - punctulatus.
  - badius, S.
  - reflexus, S.

DIAPERIADÆ.

- Uloma, D.
  - fodiens. ochracea.
- Hypophlæus, F.
  - pusillus.
- Phaleria, Latr.
  - testacea, S.
  - mimus. Not strictly a Phaleria.
- Diaperis, Geoffroy.
  - maculata, O. Hydni, F.
  - orbiculata. nigra.
  - erythrocera.
  - flavipes? F. labrosa.
  - bicornis? F. viridipennis? F.
- Eledona, Latr.
  - cornuta, F.

HELOPIDÆ.

- Helops, F.
  - vittatus, O. micans, F.
  - tenuicollis, S.
  - politus.
  - convexus.
  - obliquatus, F.
  - antennatus.
- Strongylium? Kirby.
  - corticinum.

Pytho, Latr.
- nitidus.

CISTELIADÆ.

Cistela, F.
- fuliginosa.
- marginata.
- manicata.
- collaris.
- obscura, S.
- atra, S.
- debilipes.
- sericea, S. (Long's Expedition.)
- sulphurea? L. sericea, S. (Jour. Acad. Nat. Sc.)

SERROPALPIADÆ.

Orchesia, Latr.
- fusca.

Eustrophus, Illiger.
- bicolor, F.
- quadrimaculatus.
- tomentosus, S.

Dircæa, F.
- unicolor.
- variegata.
- orbicollis.

Melandria, F.
- striata, S.
- maculata.

Hypulus, Paykull.
- quadrinotatus.

Serropalpus, Hellwig.
- linearis.
- quadrimaculatus, S.

ŒDEMERIADÆ.

Œdemera, O. (Dytilus, Fischer.)
- melanura, F.
- ruficollis.

Mycterus, Clairville.
- benecornis.

LAGRIADÆ.

Lagria, F.
- ænea, S.

PYROCHROADÆ.

Dendroides, Latr.
- Canadensis, Latr.

Pyrochroa, Geoffroy.
- flabellata, F.
- puncticollis, S.
- marginata.
- infumata, Hentz.
- elegans, Hentz.

MORDELLIADÆ.

Ripiphorus, Bosc. (Pelecotoma, Fischer.)
- pallipes.

Mordella, L.
- bidentata, S.
- nigra.
- pruinosa. serval.
- scutellaris, F. brevis.
- guttulata.

- Anaspis, Geoffroy.
  - rufa, S.

ANTHICIDÆ.

- Scraptia, Latr.
  - two species.
- Notoxus, Geoffroy.
  - anchora, Hentz.
  - monodon, F.
- Anthicus, Paykull.
  - cinctus, S.
  - amænus.
  - bigeminus.

HORIADÆ.

- Horia, F.
  - sanguinipennis, S.

CANTHARIDIDÆ.

- Meloe, L.
  - Americanus, Leach.
  - quadricollis.
  - angusticollis, S.
- Cantharis, Geoffroy.
  - marginata, F.
  - ænea, S.
  - vittata, F.
  - cinerea, F.
  - atrata, F. Pensylvanica, Degeer.

BRUCHIADÆ.

- Bruchus, L.
  - Pisi, L.
  - punctifer.
  - scutellaris. Possibly not a Bruchus.
- Anthribus, Geoffroy.
  - marmoreus, O. lunatus, F.
  - quadrinotatus, S.
- Anthribus (Rhinomacer? Latr.)
  - calvus.

CURCULIONIADÆ.

- Attelabus, L.
  - analis, Weber.
  - pubescens, S.
  - bipustulatus, F.
- Rhynchites, Herbst.
  - bicolor, F.
  - hirtus? F. brevipennis.
  - porosus.
- Rhynchites (Sapindus, Schonherr.)
  - collaris, O. rubricollis, S.
  - unicolor.
- Rhynchites (Pterocolus, Sch.)
  - ovatus, F.
- Apion, Herbst.
  - rostrum, S. nigrum? Herbst.
- Thamnophilus, Sch.
  - olyra, Herbst.
  - pandura, S.
  - marginatus.
- Ithycerus, Sch,
  - Noveboracensis, Forster. curculionoides, Herbst.

- Brentus. F. (Arrhenodes, Sch.)
  - septentrionis, Herbst. peregrinus, Herbst. Maxillosus ? O.
- Curculio, L. (Thylacites, Germar.)
  - crinitus. globulus.
- Curculio (Aphrastus, Sch.)
  - tæniatus, S.
- Curculio (Sitona, Germar.)
  - mustelinus.
  - caninus ? F.
- Curculio (Hadromerus, Sch.)
  - hilaris, Herbst.
- Curculio (Listroderes, Sch.)
  - lineatulus, S.
  - tricarinatus. Lineatulus ? S. var.
  - reticulatus.
- Curculio (Hylobrius, Germ.)
  - pales ? Herbst. Abietis ? L. macellus, G.
  - Abietis ? L. multiguttatus ? O. confusus.
  - atropos.
- Curculio (Otiorhynchus, Germ.)
  - apiculatus.
- Lixus, F.
  - rubellus.
  - marginatus, S.
  - lineaticollis. rostellatus.
- Rhynchænus, F. (Pissodes, Germ.)
  - Strobi, Peck. nemorensis, G.
- Rhynchænus (Erodiscus, Sch.)
  - myrmex, Herbst. myrmecodes, S.
- Rhynchænus (Balaninus, Germ.)
  - nasicus, S.
  - rectus, S.
  - rotundicollis.
- Rhynchænus (Orchestes, Illiger.)
  - calceatus.
- Rhynchænus (Madarus, Sch.)
  - undulatus, S.
- Rhynchænus (Baridius, Sch.)
  - modestus. picipennis.
  - obtusus.
- Rhynchænus (Cryptorhynchus, Illiger.)
  - argula, F. nenuphar. Herbst. Cerasi, Peck.
  - elegans, S.
  - terminalis. elegans ? S. var.
  - anaglypticus, S.
  - parochus, Herbst.
  - palmacollis, S.
- Rhynchænus (Ceutorhynchus, Germ.)
  - pruinosus.
  - tubularis.
  - acephalus, S.
- Rhynchænus (Mononychus, Schüppel.)
  - vulpeculus, F.
- Calandra, Clairville.(Rhynchophorus, Herbst.)
  - pertinax, O.
  - cariosa, O.
  - immunis, S.
  - cicatricosa, S.

- Calandra (proper.)
  - Oryzæ, L.
- Cossonus, Clairv. (Rhyncholus, Creutzer.)
  - corticolus, S. corticalis ? F.
  - punctulatus.
  - striatus.

BOSTRICHIDÆ.

- Hylurgus, Latr.
  - terebrans, O.
  - insidiosus.
  - apiculatus.
- Hylesinus, F.
  - aculeatus, S.
- Phloiotribus, Latr.
  - reflexus.
- Scolytus ? Geoffroy.
  - pyri, Peck. (Probably Bostrichus F. Tomicus ? Latr.)
- Tomicus, Latr.
  - pini, S.
  - septentrionis.
  - dentatus, S.
  - politus, S.
  - liminaris.
  - profundus.
  - xylographus, S.
- Bostrichus, Geoffroy. (Apate, F.)
  - basillaris, S.

CISIDÆ.

- Cis, Latr.
  - pubescens.
- Rhyzophagus, Herbst.
  - obsoletus.
- Monotoma, Herbst.
  - one species.

MYCETOPHAGIDÆ.

- Lyctus, F.
  - canaliculatus ? S. Striatus.
- Bitoma, Herbst.
  - quadriguttata, S. Synchita quadriguttata, S.
- Mycetophagus, F.
  - flexuosus, S.
  - nubilus.
- Latridius, Herbst.
  - pubescens, S.
  - inermis.
  - impressicollis.
  - denticollis.
  - urceolus.
  - punctulatus.
  - dentatus, S. Silvanus dentatus, S.
- Silvanus, Latr.
  - Surinamensis, L. frumentarius, F.
  - subdentatus.
- Trogosita, F.
  - mutica, Pal. de Beauv.
  - cinnamomea, S.
  - depressior ? Pal. de Beauv.

CUCUJIADÆ.

- Cucujus, F.
  - clavipes, O.
  - rufus, O.
  - biguttatus, S.
- Dendrophagus, Gyllenhal.
  - impressus. Cucujus oblongus ? F.
- Uleiota, Latr.
  - dubia, F.
- Parandra, Latr.
  - brunnea, F.

CERAMBYCIDÆ.

- Prionus, Geoffroy.
  - laticollis, Drury. brevicornis, F.
  - lævigatus.
  - unicolor, Drury. cylindricus, F.
- Cerambyx, L. (Stenocorus, F.)
  - atomarius, Drury. Marilandicus, F.
  - cinctus, Drury. garganicus, F.
  - undatus, F.
  - quadrigeminatus, S.
  - rigidus, S.
  - putator, Peck. villosus ? F.
  - circumflexus, F.
- Cerambyx (Clytus, F.)
  - speciosus, S.
  - nobilis.
  - pictus, Drury. Robiniæ, Forster. flexuosus, F.
  - fulminans, F.
  - undulatus, S.
  - villicus, O.
  - Ammon
  - hamatus, S.
  - caprea, S.
  - palliatus.
  - verrucosus, O. gibbosus, F.
  - erythocephalus, F.
  - supernotatus, S.
  - testaceus. (Not strictly a Clytus.)
- Cerambyx (Callidium, F.)
  - foveicolle. atropos.
  - substriatus.
  - juvencus.
  - brevilineatus, S.
  - bajulus, L.
  - violaceus, L.
  - janthinus. iconicus.
  - cucujiformis.
  - varius, O. versicolor, Turton. undatus? L.
  - ligneus. F.
  - variabilis, L. fennicus, F.
- Necydalis L. (Stenopterus, Illiger.)
  - rufa, L.
- Necydalis (Molorchus, F.)
  - bimaculata, S.
- Lamia, F.
  - confusa, S. Clytus confusus, S.
- Lamia (Acanthocinus, Megerle.)
  - acanthura. undata. subfasciata.

- Lamia (Acanthocinus, Megerle.)
  - obsoleta, O. DeGeer? fasciata? DeGeer. antennator? F. M. nigra [and obliqua, Melsheimer.
  - contusa.
  - vittaticollis.
- Lamia (Tetraopes, Sch.)
  - tetropthalma, Forster. tornator, F.
  - arator, Germar.
- Lamia (Monochamus, D.)
  - titillator, F.
  - dentator? F. Caroliniensis? O.
  - sutor, L.
  - pruinosa.
  - bifasciata.
- Lamia (Mesosa, Mergele.)
  - macula, S.
  - maculata.
  - alpha, S.
  - faceta, S.
  - aspersa, S.
- Lamia (Saperda, F.)
  - calcarata, S.
  - obliqua, S.
  - vestita, S. Appendix to Long.
  - bivittata, S.
  - tridentata, O.
  - triuncata.
  - lateralis, F.
  - inornata, S.
  - plumbea, O. tripunctata, F.
  - tetramera.
- Leptura, L. (Desmocerus, D.)
  - palliata, Forster. cyanea, F.
- Leptura (Rhagium, F.)
  - lineata, O.
- Leptura (Rhamnusium, Megerle.)
  - decolorata.
- Leptura (Pachyta, Megerle.)
  - Leonardii.
  - cyanipennis, S.
  - dehiscens.
  - canaliculata.
  - præusta. proxima? S.
  - annulicornis.
- Leptura (proper.)
  - atrata. æthiops.
  - annulata.
  - Canadensis, O.
  - veluttina, O.
  - cordifera, O.
  - nitens, Forster. zebrata, F.
  - rubrica, S.
  - proxima? S. opaca.
  - vittata, O.
  - rubricollis.
  - ruficollis, S.
  - pubera, S.
  - nubila.
  - lineola, S

Leptura, (proper.)
scalaris, S.
luteicornis, F.
calceola.
Leptura (Toxotus, Megerle.)
cærulea, S.

CRIOCERIDÆ.

Donacia, F.
palmata, O. subtilis, Ahrens.
æqualis, S.
sulcicollis.
metallica, Ahrens. S.
chalybata.
pusilla, S.
Orsodachna, Latr.
vittata, S. the hepatica, S. is a variety.
Crioceris, Geoffroy.
trivittata, S. trilineata? S.
collaris, S.
Auchenia, Thunberg.
tripla, S. Orsodachna tripla, S.
tuberculata.

HISPIADÆ.

Hispa, L.
vittata, F.
suturalis, F.
quadrata, F. rosea, Weber. marginata, S.
corbula.
pallida, S.
obsoleta, S.

CASSIDADÆ.

Cassida, L.
Argus, Herbst.
clavata, F.
aurichalcea, F.
quadrisignata.
vicina. signifer.
convolvuli.

CHRYSOMELIADÆ.

Clythra. F.
dominicana, F.
quadriguttata, S.
Chlamys, Knoch.
gibbosa, F. plicata, F. tuberosa, Knoch.
Cryptocephalus, Geoffroy.
ornatus, S.
quadriguttatus, S.
quinquelineatus.
luridus, F.
promiscuus.
normatus. sexnotatus, Melsh.
prasinatus.
Eumolphus, Klüg.
auratus, F.
pini, S.
barbatus, S.
varians.
cochlearius.

- Colaspis, F.
  - quercus, S.
  - decemnotata, S.
  - puncticollis, S.
  - ustulata.
  - quadrinotata, S.
  - imperita.
  - normalis.
  - striata, S.
  - ovata, S.
- Chrysomela, L.
  - trimaculata, F.
  - scalaris, Leconte.
  - decipiens. Weber.
  - Philadelphica, F.
  - hybrida, S.
  - pulchra F.
  - elegans, O.
  - cæruleipennis, S.
  - teres.
  - vicina.
- Chrysomela (Prasocuris, Latr.)
  - scripta, F.
  - arquata.
  - trivittata, S.
- Chrysomela (Megalamera.)
  - rhois, Forster. meticulosa, O.
- Galeruca, Geoffroy.
  - tomentosa, L. baccharidis, F.
  - puncticollis, S.
  - vittata, F.
  - gelatinariæ, F.
  - sordida.
  - rufosanguinea. S.
  - notulata.
  - notata, F.
  - duodecimpunctata, F.
  - meraca, S.
- Galeruca (Adimonia, Schranck.)
  - circumdata.
  - unicolor.
- Haltica, Geoffroy. (Ædionychis, Latr.)
  - thoracica, F.
  - abdominalis, O.
  - vians, S.
  - fimbriata, Forster. Suturella, S.
  - rugosa.
  - subvittata.
  - circumdata.
  - palliata.
- Haltica (proper.)
  - Caroliniana, F. alternata? Illiger.
  - uniguttata, S. glabrata? F.
  - tæniata. horticola.
  - triangularis, S.
  - collaris, F.
  - collata, F.
  - ænea? O.
  - chalybea, Illiger. amethystina? O. vitivora, Thomas.
  - ignita, Illiger.
  - nana. S.

Haltica (proper.)
 segetum.
 pallidicauda.
 striolata, F. var. bipustulata, F.
 pubescens, Illiger.
Haltica (Dibolia, Latr.)
 ærea.

EROTYLIDÆ.

Ropalocerus.
 fasciatus.
Tritoma, F.
 humerale, F.
 biguttata, S.
Triplax, F.
 thoracica, S.
Languria, Latr.
 linearis.
 Mozardi.
 brevicollis.

ENDOMYCHIDÆ.

Endomychus, Weber.
 lineatus, F. Eumorphus, distinctus, S.
 angulatus, S. Eumorphus angulatus, S.
 vestitus, S. Lycoperdina vestita, S.
 ferrugineus, Leconte. Lycoperdina feruginea, Leconte.
 biguttatus, S.
 geminatus.

COCCINELLIADÆ.

Coccinella, L.
 borealis, F.
 mali, S.
 novemnotata, F.
 transversa.
 transversoguttata.
 bioculata, S.
 geminata. clepsydra.
 munda.
 ursina. F.
 vigintimaculata, S.
 picta.
 media.
 proba. S.
 abbreviata, F.
 decemmaculata, F.
 tibialis, S.
 parenthesis, S.
 ternaria. multiguttata.
Coccinella (Chilochorus.)
 cacti, L.
 normata, S.
Scymnus.
 parvulus. brevis.
 querci.
 cissi.
Clypeaster, Andersch.
 fasciatus, S.

II.—ORTHOPTERA.

FORFICULADÆ.

Forficula, L.
- Two species.

BLATTIADÆ.

Blatta, L.
- Americana, L.
- Domingensis, Pal. de Beauvois.
- orientalis, L.
- Pensylvanica, DeGeer. rufescens, P. de Beauv.
- bicolor ? Pal. de Beauvois.
- parallela.

MANTIADÆ.

Spectrum, Stoll.
- femoratum, S.

ACHETADÆ

Gryllotalpa, Latr.
- Americana.

Acheta, F.
- tripunctata.
- servilis.

Acheta, (Æcanthus, Serville.)
- nivea, DeGeer.
- bipunctata ? DeGeer. cylindrica.

GRYLLIADÆ.

Gryllus, L. (Ephippiger, Latr.)
- maculatus,

Gryllus (Pterophylla, Kirby.)
- concavus, H.
- oblongifolius, DeGeer. laurifolius, L.
- curvicaudus, DeGeer.
- agilis, DeGeer.
- fasciatus ? Degeer.

Gryllus (Conocephalus, Thunberg.)
- tuberculatus ? DeGeer. ensiger.

LOCUSTIADÆ.

Acrydium, Latr.
- obscurum ? F.
- flavofasciatum ? DeGeer. torvum.
- sanguinipes ? F.
- femur-rubrum, DeGeer. erythropum, Gmelin.
  femorale, O.

Locusta, L.
- apiculata. tuberculata, P. de Beauv. F ?
- Carolina, L.
- equalis, S.
- sulphurea ? F. periscelidis,
- viridifasciata, DeGeer. { Virginiana, F. chrysomela, Gmelin. hemiptera, P. de Beauv. marginata, O.
- sulphurea, Pal. de Beauv.
- radiata.
- eucerata.
- cerineipennis.
- curtipennis.

- Tetrix, Latr.
    - laterale, S.
    - ornatum, S.
    - sordidum.
    - parvipenne.

III.—HEMIPTERA.

PENTATOMADÆ.

- Scutellera, Lamarck. (Tetyra, F.)
    - alternata, S.
    - cinctipes, S. dubia ? Pal. de Beauv.
- Scutellera (Thyreocorus, Schranck.)
    - histeroides. unicolor ? P. de Beauv.
- Pentatoma, O.
    - arborea, S.
    - Pensylvanica ? DeGeer. hilaris. Tiliæ.
    - obesa. delia.
    - punctipes, S. conspersa. serva.
    - punctipes, Pal. de Beauv.
    - senilis.
    - saucia.
    - inserta.
    - nervosa.
    - dimidiata.
    - undata.
    - clauda, S.
    - exapta, S.
    - icterica, L.
    - maculiventris.
    - serieventris.
    - carnifex, F.
- Pentatoma (Cydnus, F.)
    - spinifrons, S.
    - ligatus, cinctus ? Pal. de Beauv.
    - bilineatus, S.

COREIDÆ.

- Coreus, F.
    - galeator, F.
    - tristis, DeGeer. ordinatus S.
    - lateralis, S.
    - catenarius.
    - striatipennis.
- Lygæus, F. (Alydus, F.)
    - eurinus, S.
    - vittinasus.
- Lygæus (Anisoscelis, Latr.)
    - prominulus.
- Lygæus (Berytus, F.)
    - spinosus ? S. muticus.
- Lygæus (proper.)
    - turcicus, F.
    - numenius.
    - geminatus.
- Lygæus (Pachymera, Lepeletier and Serville.)
    - constricta.
    - bilobata.
    - mavortia. (Astemma ?)

Salda, F.
- pedunculata.
- bullata.

Myodocha, Latr.
- petiolata.

Astemma, Latr.
- coracina. (Miris ?)

Miris, F.
- flagellatus,
- dorsalis.
- vagans ? F.
- brevidapex.
- bivittatus.

Capsus, F.
- rapidus.
- inops.
- quadrivittatus.
- invitus.
- oblinitus.
- cardinalis.
- testudineus.
- lugubris.
- dislocatus.
- sanguinarius.
- trifidus.
- insitivus.
- virens ? F
- famelicus.
- bracteatus.
- alticus. (Perhaps not of this genus.)

CIMICIDÆ

Syrtis, F.
- erosa, F.

Tingis, F.
- marmoratus.

Aradus, F.
- sanguineus.
- penultimus.
- muticollis.

Cimex, L.
- lectularius, L.

Reduvius, F.
- personatus ? L. mimicus.
- pectoralis.
- cinctus, F.
- diadema, F.
- multispinosus, DeGeer. raptorius, S.

Reduvius (Nabis ? Latr.)
- pectoralis.

Reduvius (Zelus, F.)
- acanthogonius.

Reduvius (Ploiaria, Scopoli.)
- simplicipes.
- brevipennis, S. longipes ? DeGeer.
- errabundus.

Leptopus, Latr.
- alternatus.

Acanthia, Latr.
  coriacea.

HYDROMETRADÆ

Gerris, F.
  remigis.
  marginatus.
  humilis.

Velia, Latr.
  collaris.

NEPADÆ.

Belostoma, Latr.
  Americana? F. grisea.
  sordida.
  fluminea.

Nepa, L.
  apiculata.

Ranatra, F.
  fusca, Pal. de Beauv.

NOTONECTIADÆ.

Notonecta, L.
  Americana, F.
  maculata, O. lineata? Forster.
  undulata.

Notonecta (Corixa, Geoffroy.)
  interrupta, S.
  alternata, S.

IV.—OMOPTERA.

CICADIADÆ.

Cicada, O.
  tibicen? L.
  pruinosa, S.
  septemdecem, L.

FULGORIADÆ.

Otiocerus, Kirby
  Coquebertii, Kirby.
  DeGeerii, Kirby.

CERCOPIADÆ.

Flata, F.
  bivittata, S.
  stigmata, S.
  pruinosa,
  opaca.

Membracis, F.
  bimaculatus, F.
  monticola? F. Cissi.
  urticæ.
  bubalus, F.
  taurinus.
  festivus.
  arquatus.
  latipes, S.
  binotatus, S.
  sinuatus, F.
  concavus, S.
  marmoratus.
  univittatus.
  vau.

Cercopis, F. (Aphrophora, Germar.)
obtusa, S.
quadrangularis, S.
parallela, S.
ignipecta.
Jassus, F.
semindus.
clitellaria.
novellus.
subfasciatus.
farctus.
areatus.
immistus.
irroratus.
Tettigonia, O.
octolineata, S.
unilineata.
mellipes.
quadrivittata.
coccinea, Forster.
hieroglyphica.
vitis, H. basilaris? S.
squalisimila.

APHIDIDÆ.

Thrips, L.
one species.
Aphis, L.
caryæ.
and many other species.
Aphis (Eriosoma, Leach.)
lanigera, L.

COCCIADÆ.

Coccus, L.
arborum linearis, Geoffroy.
cryptogamus, Dalman.
Hesperidum, L.
Adonidum, L.
and others undetermined.

V.—NEUROPTERA.

LIBELLULADÆ.

Libellula, L.
pulchella, Drury. bifasciata, F. versicolor? F.
Lydia, Drury. trimaculata, DeGeer. F?
quadrupla.
pruinosa. trimaculata? F.
exusta.
semicincta.
tenera.
ternaria.
rubicunda.
cynosura.
Berenice, Drury.
Julia.
rubicundula.
simplicollis.
Æshna, F.
heros, F.
Æshna (Gomphus, Leach.)
Junius, Drury.
clepsydra.

- Æshna (Gomphus,) L.
  - obsoleta.
  - furcillata.
  - janata.
  - fraterna.
  - vinosa.
  - obliqua.
  - transversa.
- Agrion, F.
  - materna. virgo gamma, Drury.
  - fugitiva.
- Agrion, (Calepteryx, Leach.)
  - opaca.
  - æquabilis.
- Agrion (Lestes, Leach.)
  - eurina.
  - basalis.
  - rectangularis.
  - hastata.
  - verticalis.
  - insipiens.

EPHEMERADÆ.

- Ephemera, L. (Baetis, Leach.)
  - eurina.
  - fuscicostata.
  - confusa.
  - amœnicauda.
  - luteipennis.
- Ephemera (Cloeon? Leach.)
  - leuconeura.
  - scripticostata.
- Ephemera (proper.)
  - bispinosa.

PANORPIADÆ.

- Panorpa, L.
  - fasciata, L.

MYRMELEONTIDÆ.

- Ascalaphus, F.
  - maculatus? O.

HEMEROBIIDÆ.

- Hemerobius, L.
  - irroratus, S.
  - mononeurus.
  - perla? L.

SEMBLIADÆ.

- Corydalis, Latr.
  - cornutus, L.
- Chauliodes, Latr.
  - pectinicornis, L.
  - denticornis.
  - serricornis, S.
- Sialis, Latr.
  - maurus.

PERLIADÆ.

- Perla, Geoffroy.
  - immarginata, S. (Sialis.)
  - isogona.
  - semifasciata.

Perla, (Nemoura, Latr.)
convoluta.
debilipennis.

MANTISPIADÆ.

Mantispa, Illiger.
pagana, S.

TERMITIDÆ.

Termes, L.
agrarius.
domesticus.
Psocus, F.
gregarius.
Atropos, Leach.
pulsatorius, L.

PHRYGANEADÆ.

Phryganea, L.
semifasciata, S
subfasciata, S.
radiata.
argenteornata.
intaminata.
coagulata.
elongatula.
sericea.
stygipes.
plurifaria.
dislocata.
obsoleta.
debilipes.
undulata.
quadrula.
Phryganea (Leptocerus, Leach.)
variegata. hieroglyphica.
maculicornis.
tarsata.
nubila.
alternicornis.

VI.—HYMENOPTERA.

TENTHREDINIDÆ.

Cimbex, O.
Americana, Leach.
ulmi.
Tenthredo, L. (Schyzocera, Latr.)
calceola.
Tenthredo (Lophyrus, Latr.)
compar? Leach. Americana? Leach.
flavida.
Tenthredo (Hylotoma, F.)
Macleayi? Leach.
pectoralis, Leach.
clavicornis, F.
erythrosoma? Leach. scutellata.
Tenthredo (Allantus, Jurine.)
sambuci.
verticalis? S.
basilaris? S.

Tenthredo (Allantus, Jurine.)
media.
tacita.
melisoma.
trosula.
rufipes, S.
trisyllabus.
atroviolacea.
obesa.
marginicollis.
coronata.
tarda.

Tenthredo (Selandria, Leach.)
vitis, H.
barda.
pygmæa.
cerasi, Peck.
halcyon.

Tenthredo (Dosytheus, Leach.)
sericea, S.
unicolor? P. de Beauv.
arvensis, S.
collaris, S.
bicolor, P. de Beauv.
aprica.

Tenthredo (Emphytus, Leach.)
inornata, S.
tarsata.
mellipes.
aperta.

Tenthredo (Cræsus, Leach.)
septentrionalis, F.

Tenthredo (Nematus, Jurine.)
integra.
melanocephala.
ventralis.
pallicornis.
fulvipes.
labrata.
stigmata.
monochroma.

Tenthredo (Cladius, Klug.)
isomera.
dorsalis. (Acordulecera.)

Tenthredo (Lyda, F.)
maculiventris.
circumcincta, Klug.
ochrocera.
scripta, S. Tarpa scripta, S.
rufofasciata.
calceata.

XIPHYDRIADÆ.

Xyela, Dalman.
ferruginea, S,
infuscata.

Cephus, Latr.
abbreviatus.
integer.

Cephus, Latr.
- heteropterus.
- filicornis.

Xiphydria, Latr.
- albicornis.
- mellipes.

UROCERIDÆ.

Oryssus.
- hæmorrhoidalis.
- maurus.
- affinis.

Sirex, L.
- albicornis, F.
- abdominalis.

Sirex (Tremex, Jurine.)
- columba, L.

EVANIADÆ.

Fænus, F.
- irritator.

Evania, F.
- appendigaster? Latr.

Pelecinus, Latr.
- polycerator, F.
- clavator, Latr.

ICHNEUMONIDÆ.

Pimpla, F.
- atrata, F.
- lunator, F.
- irritator, F.

Cryptus, F.
- annulipes,
- mellipes,
- facilis.
- inquisitor, S.
- ectypus.
- hispæ.
- pleuriticus.
- versicolor.
- polyspeirus.
- leucotelus.
- facetus.
- calceatus.
- laxus.
- velox.
- tenellulus.
- cardinalis.
- crescentus.
- bucephalus.
- clyti.
- subclavatus.
- palmapectus.
- subspinosus.
- isochromus.
- attractus.
- recurvulus.
- spinulosus.

Ophion, F.
- bilineatus, S.

- **Ophion, F.**
    - geminatus, S.
    - vitticollis.
    - dentulatus.
    - cecropiæ.
    - glabratus.
    - mundus.
    - flavicornis, S. Anomalon flavicornis, S.
    - morio, F.
    - analis, S.
    - relictus, F.
- **Ichneumon, L. (Trogus Panzer.)**
    - fulvus ? F. pennator ? F. ischiadicus.
    - atratus.
- **Ichneumon (proper.)**
    - concitator S.
    - devinctor, S.
    - multor, S.
    - basiator, S.
    - alternator, S.
    - centrator, S.
    - cingor. S.
    - unifasciatorius, S.
    - lusorius, S.
    - dimelapsus.
    - stolophorus.
    - extaricus.
    - calitergus.
    - ferrugator, Swederus.
    - residuus, S.
    - brevinctor, S.
    - emarginatus.
    - orbitarius.
    - mellipectorius.
    - melisomus.
    - spatiosus.
    - emarginatulus.
    - platicerus.
    - leucopterus.
    - plantaris.
    - eurostus.
    - biarquatus.
    - ligatus.
    - vau.
    - surcularis.
    - trichocerus.
    - suturalis.
    - metathoracicus.
    - otiosus, S.
    - impiger.
    - milvus.
    - paratus.
    - hospes.
    - morulus.
    - petiolatus.
    - exulans.
    - famelicus.
    - baculus.
    - mellilabrus.
    - anxifer.
    - aleatorius.
    - ales.

- Acænitus, Latr.
    - amœnus.
- Bracon, F.
    - populator ? S. maturor.
    - rugulosus.
    - operculatus.
    - palpatorius.
- Microgaster, Latr.
    - carpata.
- Sigalphus, Latr.
    - puppius.
    - patulus.
    - socius.
- Chelonus, Jurine.
    - corrugatus.
    - sericeus.
    - dislocatus. (Not strictly a Chelonus.)

DIPLOLEPIDIDÆ.

- Ibalia, Latr.
    - maculipennis.
- Figites, Latr.
    - pini.
    - melisoma.
- Diplolepis, Geoffroy.
    - nubilipennis.
    - flagellatus.
    - impolita.
    - devius.
    - potentillæ.
    - dichocerus.
    - semipicea.
    - oneratus.
    - confluentus.

CHALCIDIDÆ.

- Leucospis, F.
    - affinis, S.
- Chalcis, F.
    - octonotata.
- Torymus, Dalman.
    - semiauratus.
    - azaleæ.
    - amethystinus.
- Perilampus, Latr.
    - hyalinus.
- Pteromalus, Latr.
    - arctiæ.
    - vanessæ.
    - clisiocampæ.
    - lepturus.
    - obesus.
- Eurytoma, Illiger.
    - hordei, H.
    - studiosa.
- Eulophus, Geoffroy.
    - one species.

PROCTOTRUPIADÆ.

- Proctotrupes, Latr.
    - cordatus, S.

Psilus, Jurine.
terminatus.
Ceraphron, Jurine.
platycephalus.

CHRYSIDIDÆ.

Chrysis, L.
pacifica, S.
cærulans, F.
Chrysis (Hedychrum, Latr.)
speculum.

FORMICIADÆ

Formica, L.
Pensylvanica, DeGeer. herculeana ? F.
melineura.
incisuralis.
quadrata.
subsericea.
bilobata.
petulca.
Formica (Myrmica, Latr.)
inflecta.

MUTILLIADÆ.

Mutilla, L.
ferrugata ? F.
pervaga.
undulata.
dislocata. (Not strictly a Mutilla.)
Mutilla (Myrmosa, Latr.)
unicolor, S.
Mutilla (Methoca, Latr.)
pacalis.

SCOLIADÆ.

Tiphia, F.
tarda.
inornata, S.
Plesia, Jurine.
costata.
Scolia, F.
plumipes, Drury.

SAPYGIADÆ.

Sapyga, Latr.
peptica.
centrata.

POMPILIADÆ.

Cerophales, Latr.
bipunctata, S.
denticulata.
piciventris.
Pompilus, F.
tropicus ? F. marginatus ? S.
atroviolaceus.
tarsatus.
solicitus.
vafer.
biguttatus, F.
architectus.
speirapterus.

Pompilus, F.
  debilis.
Miscus, Jurine.
  stygicus.
  petiolatus.

SPHEGIADÆ.

Sphex, L. (Ammophila, Kirby.)
  conditor. fulvicaulis.
  lugubris,
  gryphus.
Sphex (proper.)
  ichneumonea, L.
  Pennsylvanica, Pal. de Beauv.
  labrosa.
  apicalis. (Probably not a true Sphex.)
Sphex (Pelopæus, F.)
  flavipes, F.
  cærulea. L. cyanea, F.
  affinis, F.

BEMBICIDÆ.

Bembex, F.
  fasciata, F.
Monedula, Latr.
  ventralis ? S. vigilans.

LARRIADÆ.

Lyrops, Illiger.
  aurulenta.
Larra, F.
  argentata, Pal. de Beauv.
  Pennsylvanica, Pal. de Beauv.
  subita.
Astata, Latr.
  unicolor, S.
Nysson, Latr.
  laterale.
Tripoxylon, Latr.
  clavatum.
  atritarse.
Oxybelus, Latr.
  quadrinotatus, S.
  emarginatus.

CRABRONIADÆ.

Crabro, F.
  decemmaculatus, S.
  glauconotatus.
  sexmaculatus, S.
  confertus.
  famelicus.
  complanatus, S,
  gryphus.
  argus.
  pegasus.
  pusillus.
  scutellatus, S.
  tibialis, S.
Cemonus, Jurine. (Pemphredon, F.)
  concolor, S. Pemphredon concolor, S.

Cemonus.
- inornatus, S.
- annulatus. (Stigmus ?)

Mellinus, F.
- bimaculatus.

Cerceris, Latr.
- deserta, S.
- baridius.

Philanthus, F.
- vertilabris, S.
- obsoletus.
- viatus.
- impunctatus.
- erratus.

VESPIADÆ.

Vespa, L. (Odynerus, Latr.)
- quadricornis, L. cincta, DeGeer. uncinata, F.
- pluricincta.
- incincta ? F.
- Dædalus.
- oculata.
- parietina ? L.
- debilis.
- distans. } allied species not strictly belonging to Odynerus.
- flavicornis. }
- atricornis. }

Vespa (Eumenes, Latr.)
- fraterna, S.

Vespa (Polistes, F.)
- fuscata, F.
- promethea.

Vespa (proper.)
- maculata, L.
- fraterna. arenaria ? L.
- maculifrons.
- cuneata, F.
- inæqualis.

ANDRENIADÆ.

Andrena, F.
- sericea, Forster. viridula, F.
- nigricornis, F.
- smaragdina.
- amœna.
- furva.
- calceata.
- ludibunda.
- paganica.
- fulviana.
- ligata.
- agilis.
- opposita.
- dubia.
- mera.
- inornata.
- flavinasus.
- leucopus.
- frugalis.
- noticauda.

Andrena (Sphecodes. Latr.)
    dichroa.

APIDÆ.

Xylocopa, F.
    victima.
Ceratina, Latr.
    dupla.
Megachile, Latr.
    latimana, S.
    subsinuosum.
    integrum.
    dimidiatum.
Osmia, Panzer.
    lignaria.
    pacifica.
Stelis, Panzer.
    interrupta.
Cælioxys, Latr.
    octodentata, S.
Epeolus, F.
    mercatus, F.
    donatus.
Nomada, F.
    decora.
    vincta.
    interrupta.
    bisignata, S.
Melecta, Latr.
    inermis.
Eucera, Latr. (Melissodes, Latr.)
    tibialis.
    pruinosa.
    erratica.
    rustica.
    sexdentata.
Bombus, F.
    Americanorum, L.
    elatus. F.
    dimidiatus.
    Virginicus, F.
    fervidus, F. nidulans ? F.
    cultor.
    impatiens.
    ternarius.
Apis, L.
    mellifica, L.

VII.—LEPIDOPTERA.

PAPILIONIADÆ.

Papilio, L.
    Turnus, L.
    Asterius, Cramer.
    Troilus, L.
Pontia, F.
    oleracea, H.
Colias, F.
    Philodice, Godart.

Argynnis, F.
  Idalia, Drury.
  Aphrodite, F. *var.* Daphnis, Cramer. Cybele, F.
Melitæa, F.
  Phaeton, Drury.
  Myrina, Cramer.
  Cocyta, Cramer. Pharos? Drury. Tharos? Cr.
Vanessa, F.
  Antiope, L.
  urticæ, L.
  interrogationis, F.
  Progne, Cramer and Godart.
  furcillata, S.
Cynthia, F.
  Atalanta, L.
  cardui, L.
  Huntera, F. belladona, Petiver. Iole, Cr.
  Lavinia, F. Orythia, Smith—Abbot.
Hipparchia, F.
  Alope, F. & Godart.
  Andromacha, Hubner.
  Eurytris, F. Cymele, Cramer.
  semidea, S. fortunata? F.
Limenitis, F.
  Ephestion, Stoll. Ursula, F.
  Arthemis, Drury.
  Misippus, L.
Danaus, Latr.
  Archippus, F. Plexippus, Cramer.
Lycæna, F.
  phlæas? L.
Thecla, F.
  Damon, Cramer.
  Pan? Drury.
  and five more species.
Polyommatus, Latr.
  Argiolus, L.
  and two more species.

HESPERIADÆ.

Hesperia, F.
  Clarus, Cramer. Tityrus, F.
  Bathyllus, Smith-Abbot.
  Juvenalis, F.
  Juvenalis, *var.* Smith-Abbot.
  and eight more species.

SPHINGIADÆ.

Smerinthus, Latr.
  excæcata, Smith-Abbot.
  integerrima.
  myops, Smith-Abbot.
  geminata, S.
  juglandis, Smith-Abbot.
Sphinx, L.
  lineata, L.
  epilobii.
  Carolina, L.
  ligustri? L.
  gordius, Cramer.

Sphinx, L.
kalmiæ, Smith-Abbot.
Crantor, Cramer. Achemon, Drury.
satellitia, L. Licaon? Cramer.
Hylæus, Drury. prini, Smith-Abbot.
pampinatrix, Smith-Abbot. Myron? Cr.
azaleæ? Smith-Abbot. Chœrilus? Cr.
and three more species.
Thyreus, Swainson.
Abbotii, Swainson.
Macroglossa, Scopoli.
Nessus, Cramer.
Sesia, F.
pelasgus, Cramer.

ÆGERIADÆ.

Ægeria, F.
tricincta.
cucurbitæ, H.
exitiosa, S. persicæ, Barton.
fulvicornis, S.
fulvipes.
pyri, H.
tipuliformis, L.
and four more species.
Thyris, Illiger.
maculata.

ZYGÆNIADÆ.

Glaucopis, F.
pholus, F.
Aglaope, Latr.
dispar.

BOMBYCIADÆ.

Hepialus, F.
argenteomaculatus.
Cossus, F.
robiniæ, Peck.
crepera.
Attacus, Germar.
Luna, L.
Polyphemus, L.
cecropia, L.
Promethea, Drury.
Saturnia, Schranck.
Proserpina, F.
Io, F.
Ceratocampa, (Ceracampa, Kirby.)
regalis, F.
imperialis, F.
Dryocampa.
senatoria, Smith-Abbot. Astynome? O.
rubicunda, F.
Gastropacha, Ochsenheimer.
velleda, Stoll.
and another species.
Clisiocampa, Curtis.
castrensis, Smith-Abbot.
neustria, Smith-Abbot.
pyxidifera? Smith-Abbot.

Bombyx, F.
    mori, L.

NOTODONTIADÆ.

Pygæra ? Och.
    albifrons, Smith-Abbot.
    ministra, Drury.
    and another species.
Notodonta, Och.
    anguina, Smith-Abbot.
    concinna, Smith-Abbot.
    unicornis, Smith-Abbot.
    aurora, Smith-Abbot.
    grata, F. (Not strictly a Notodonta.)
    and four more species.
Clostera, Hoffmansegg.
    two species.
Cerura, Schranck.
    two species
Limacodes, Latr.
    scapha.
    and another ? species.

ARCTIADÆ.

Arctia, Schranck.
    isabella, Smith-Abbot.
    acria, Drury. male, caprotina, Drury.
    Virginica, F.
    textor, H.
    virgo, Smith-Abbot.
    phyllira, Smith-Abbot.
    figurata, Drury.
    phalerata,
    Egle, Drury.
    tessellaris, Smith-Abbot.
    caryæ.
    and another species.
Dasychira ? Hübner.
    firmiana. Cramer. torrefacta, Smith-Abbot
    and another species.
Orgyia, Och.
    antiqua ? L.
    and two more species.

LITHOSIADÆ.

Psychemorpha.
    maculata.
Callimorpha ? Latr.
    militaris.
Lithosia, F.
    Bella, L.
    and seven more species.

NOCTUADÆ.

Erebus, Latr.
    odorus, Drury.
Catocala, Och.
    nupta, L.
    consors, Smith-Abbot.
    Epione, Drury.
    and six more species.

Noctua, F.

pyramidea ? L.
aceris, Smith. Abbot.
devastator, Brace.
oleracea.
verruca, F.
iota, Cramer.
cingulata.
brassicariæ ? F.
libatrix, F.
Emmedonia, Cramer.
Erichtea, Cramer.
lunata, Drury.
squamularis, Drury.
and ninety more species.

GEOMETRADÆ.

Geometra, Hübner.

vernata, Peck. brumata ? L.
catenaria, Drury.
undulata ? F.
sospeta, Drury.
transversata ? Drury.
vibicaria ? Cramer.
serrata, Drury.
and fifty nine more species.

Platypteryx, Laspeyeres.

erosa.

PYRALIDÆ.

Herminia, Latr.

eight species.

Margaritia ? Stephens.

one species.

Pyralis, Hübner.

farinalis, L.
atralis ? F.
and five more species.

TORTRICIDÆ.

Tortrix, Hübner.

pomona, L.
and thirty two more species.

TINEADÆ.

Galleria, F.

cereana, F.
and three more species.

Crambus, F.

nivalis, Drury.
humuli.
aspergillus, Coquebert, Bosc.
and twenty six more species.

Yponomeuta, Latr.

two species.

Tinea, L.

glandis.
pellionella, L.
and ten more species.

Pterophorus, Geoffroy.

four species.

VIII.—STREPSIPTERA.

Xenos, Rossi.
- Peckii, Kirby.

IX.—DIPTERA.

CULICIDÆ.

Culex. L.
- cingulatus, F. molestis, Wiedeman.
- damnosus, S.
- colon.
- ciliatus, F.
- pungens? W.

Anopheles, Meigen.
- guttulatus. quadrimaculatus? S. var.

TIPULADÆ.

Chironomus, Meig.
- albitarsis.
- claracollis.
- lateralis.

Tanypus, Meig.
- biplagiatus.

Ceratopogon, Meig.
- debilipes.

Ctenophora, Meig.
- abdominalis, S.

Pedicia, Latr.
- goniphora. rivosa? L.

Tipula, L.
- alternata, S.
- nubilis.
- trivittata, S.
- flavicans, F.
- alternata.
- ferruginea, F.
- tricolor, F.
- vittipennis. tricolor? F.

Ptychoptera, Meig.
- clavipes, L.

Limnobia, Meig.
- monochroma.
- rostrata, S.

Trichocera, Meig.
- scutellata? S. Campylomyza scutellata? S.

Chionea, Dalman.
- valga.

Rhyphus, Latr.
- alternatus, S.

Mycetophila, Meig.
- discoida, S.

Leia, Meig.
- triplagiata.
- ziczac.

Sciara, Meig.
- obscura.

Simulium, Latr.
- calceatum.

- Scatopse, Geoffroy.
  - nitida.
- Penthetria, Meig.
  - lugubris.
- Dilophus, Meig.
  - fraternus.
- Bibio, Geoffroy.
  - femorata, Wied.
  - brunnipes, F.
  - albipennis, S.
  - articulosa.

ASILIADÆ.

- Asilus, L. (Laphria, Meig.)
  - thoracicus, F.
  - atribarbis, S.
  - flavicollis, S.
  - posticatus, S.
  - fulvicauda, S.
  - sericeus, S.
  - tergissus? S.
  - glabratus? S.
  - flavicollis, S.
  - saffranus, F.
  - glabratus, S.
- Asilus (Dioctria, Meig.)
  - octopunctatus, S.
- Asilus (proper.)
  - sericeus, S.
  - heros? W.
  - æstuans, L.
  - vorax.
  - apicalis, W.
  - glauconotatus.
  - ansatus.
- Hybos, Meig.
  - elevatus.
- Empis, L. (Ramphomyia, Meig.)
  - atritarsata.
- Cyrtus, Latr. (Acrocera, Meig.)
  - obesus.
- Cyrtus (Henops, Illiger.)
  - fasciatus.

ANTHRACIDÆ.

- Bombylius, L.
  - æqualis, F.
  - fulvus, W.
- Anthrax, Scopoli.
  - morioides, S.
  - scapularis.
  - analis? S.
  - lateralis, S.

RHAGIONIADÆ.

- Thereva, Latr.
  - plagiata.
  - nigra, S.
  - notata, W.
  - aurata.
  - frontalis, S.

Leptis, F.
    ornata, S.
    humeralis.
    trifasciata.
    auricincta.
    plumbea ? S.

DOLICHOPIDÆ.

Dolichopus, Latr.
    atricornis.
Porphyrops, Meig.
    quadriplagiatus.
Psilopus, Meig.
    sipho, S. Dolichopus sipho, S.
    scutellatus.
Platypeza, Meig.
    appendiculata.
Scenopinus, Latr.
    pallipes, S.

TABANIADÆ.

Tabanus, L.
    atratus, F.
    cinctus, F.
    lineola, F.
    divisus.
    lieneatus, F.
    molestis ? S.
Chrysops, Meig.
    ferrugatus ? F. vau.
    confusus.
    vittatus, W.
    ischiacus.

XYLOPHAGIDÆ.

Mydas, F.
    filata, L. clavata ? Drury, F.
Xylophagus, F.
    heros.
    fascipennis.
    politus.
    incisuralis.
Cœnomyia, Latr.
    pallida, S.
Beris ? Latr.
    fuscitarsis.

STRATYOMYADÆ.

Stratyomys, Geoffroy.
    viridicincta.
    abdominalis.
    intermedia, W.
    ischiaca.
    amœnifrons.
    quadripunctata.
Sargus, F.
    scutellatus.
    decorus, S.

SYRPHIADÆ.

Volucella, Geoffroy.
- basalis.

Sericomyia, Meig.
- tuberculata.

Eristalis, Meig,
- pterelas.
- fascicollis.
- posticatus ? F.
- sincerus.
- pervagus.
- saxorum.

Helophilus, Meig.
- appensus.

Syrphus, Latr. (Scæva, F. and Say.)
- concavus, S.
- quadratus, S.
- lachrymosus, S.
- vittatifrons.
- teretus,
- simulatus.
- angulatus.
- encaustus.
- cylindricus, S.
- obliquus.
- geminatus ? S.
- marginatus ? S.

Chrysogaster, Meig.
- ruficornis.

Baccha, Meig.
- aurinota.

Sphecomyia, Latr. (Pyrgota ? W.)
- undata.
- valida.

Psarus, Latr.
- quadrifasciatus, S. Paragus quadrifasciatus, S.

Merodon, Meig.
- bardus, S. Milesia barda, S.
- tudicornis.
- curvipes. W.

Xylota, Meig.
- ejuncida, S.
- proxima, S.
- hæmatodes, S.

Milesia, Latr.
- ornata, F.
- obliqua.
- excentrica.
- analis.
- ischiaca.
- verbosa.
- gnava.

Rhingia, Scopoli.
- nasica, S.

ŒSTRIADÆ.

Œstrus, L.

buccatus, F. cuniculi ? Clarke.
equi, L.
ovis, L.
bovis, L.

CONOPIADÆ.

Conops, L. (Systropus ? W

sagittaria, S.
interrupta.

Myopa, F.

vesiculosa.

Stomoxys, Geoffroy.

calcitrans ? L.
pallida.

MUSCIADÆ.

Echinomyia, Duméril.

obesa. bombylans ? F.
tessellata ? F.

Gonia, Meig.

vertebrata.
basalis.
tarda,

Gymnosoma, Meig.

rotundata, L.

Trichopoda, Latr.

jugatoria, S. Phasia jugatoria, S.

Ocyptera, Meig.

lateralis.
galerucæ. (Perhaps not a true Ocyptera.)

Melanophora, Meig.

stygia.

Tachina, F.

plagiata.
algens, W.
vivida. hirta ? Drury.
futilis. vanessæ.
noctuæ.
conica.
incauta.
rubidapex.
errabunda.

Dexia, Meig.

lateralis.

Musca, L.

vomitoria, L.
domestica ? L.
harpyia.
regina ? Meig.
amœna.
hirticollis.

Sarcophaga, Meig.

carnaria, L.
Georgina, W.

Anthomyia, Meig.

lunatifrons.

- Anthomyia.
  - timida.
  - notatifrons.
  - calceola.
  - ischiaca.
  - reces. raphani.
  - goniphora.
  - lenis.
- Borborus, Meig. (Sphærocera? Latr.)
  - planipes.
- Cordylura, Fallen.
  - placida.
- Scatophaga, Latr.
  - postilena.
- Loxocera, Latr.
  - atricornis.
- Lissa, Meig. (Lissomyia, Say, Mss.)
  - polita.
- Tetanura, Meig.
  - pallida.
- Sapromyza, Fallen.
  - subfasciata.
- Tetanocera, Duméril.
  - cauta.
  - cribraria.
- Calobata, Meig.
  - antennæpes, S.
  - agilis.
- Diopsis, L. (Sphyracephela, Say.)
  - brevicornis, S.
- Sepsis, Fallen.
  - cylindrica, F.
  - putris, L.
- Ortalis, Fallen.
  - cerasi, L.
  - colon.
  - nuphera.
- Trypeta, Meig.
  - sepentaria.
  - tribulis.
  - quadrifasciata.
  - trifasciata.
  - cinctipes.
  - albiscutellata.
  - picta, F.
- Lauxania, Latr.
  - lapsans.
- Lonchæa, Fallen.
  - polita.
- Phora, Latr.
  - velox.

HIPPOBOSCIADÆ.

- Olfersia, Leach.
  - Americana, Leach.

X.—APTERA.

- Pulex, L.
  - irritans, L.

The first edition of the preceding list of insects was chiefly prepared during the year 1830; but, before its publication in 1833, all the species, whether named or not, which were included in the several orders, were enumerated as below.

I.	Coleoptera	994
II.	Orthoptera	44
III.	Hemiptera	102
IV.	Omoptera	54
V.	Neuroptera	91
VI.	Hymenopetera	388
VII.	Lepidoptera	428
VIII.	Strepsiptera	1
IX.	Diptera	247
X.	Aptera	1
		2350

I believe this to be the first instance in which the public has been presented with any thing like a complete list of the insects of any part of our country;* and, in making this and the subsequent attempt, I have had before me not one of the numerous catalogues of insects which have been published in Europe. Many of the most valuable, important, and standard works on Entomology are known to me only by name! they are beyond the means of an individual to procure, and are not to be found in our public libraries, which are lamentably deficient in the most approved works on this subject. In the present state of the science, entomology cannot advantageously be pursued without books, and collections from other countries for study and comparison: for the want of these the second edition of this catalogue, though much enlarged, is very far from being complete; a great number of our insects have necessarily been left without names, it being found impossible, without consulting authorities inaccessible to me, to refer them even to their proper genera. This is more particularly the case with the Lepidoptera, the list of which is now reprinted without alteration from the first copy.

To the names of insects, which have been ascertained by means of published descriptions, are annexed the names or initials of the *first* describers, together with some of the most common Synonyms which have been imposed by subsequent entomologists. Those without such authorities are, so far as I can ascertain with my limited means of information, new species, which remain to be described hereafter. In those cases where two or three different names have been proposed for an undescribed insect I have thought proper to retain them, on account of the uncertainty as to which will be finally adopted and sanctioned when the insect is described.

Mr. Say, the author of the 'American Entomology,' has done me the honor to name a large number of my new species, and has rendered me important assistance in determining many of the genera, particularly in the orders Omoptera and Diptera.

It is not improbable that some species, which are to be found in collections in this vicinity, are omitted in the catalogue; for in drawing it up, (with the exception of a few remarkable insects, which a single examination sufficed to determine and fix in the recollection,) I have deemed it expedient, on account of the importance of having them always accessible for the purpose of examination and comparison, to confine myself to the insects in my own collection. I have included in the catalogue some insects which, though found beyond the boundaries of the State, may eventually be detected in Massachusetts. For these, and an immense number of duplicates, I am indebted to my friend the Rev. L. W. Leonard of Dublin, N. H., who has still more increased my obligations to him by his disinterested liberality in sending me even the rare and undescribed insects of which he possessed no duplicates. Dr. D. S. C. H. Smith has kindly supplied me with a suit of insects from Sutton, Mass., among which were nearly a hundred species new to my collection. My acknowledgments are due also to Wm. Oakes, Esq., of Ipswich, particularly for the water-beetles; and to Prof. N. M. Hentz, formerly of Northampton, to Drs. Pickering, Gould, and J. S. C. Greene, Mr. John Randall, Mr. T. Nuttall, Mr. John Bethune, and Miss D. Dix, for several interesting insects. Even with these valuable accessions the present list must fall very far short of the actual number of species or kinds existing in this Commonwealth. The proportion of insects to plants has been stated to be six species of the former to one of the latter. The flowering plants of Massachusetts amount to above 1200 species; hence our insects cannot be much less in number than 7000 species.

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* The Catalogue of the Rev. F. V. Melsheimer, the only one which has ever been published, is confined to the Coleoptera, and was printed at Hanover, Pennsylvania, in 1806.

T. WILLIAM HARRIS,
Librarian of Harvard University.

Cambridge, (Mass.) Oct. 16, 1834.

IX.—RADIATA.

This extensive class of animals has yet received but little attention in Massachusetts; comprehending, as it does, creatures of not much use to man, and for the most part inhabiting places out of the reach of common observation. In respect to some of them, also, it seems not yet to be agreed, whether they ought to be regarded as animals or plants. Through the assistance of Dr. Gould, I am able to mention a few genera and species. But I hope the deficiency of the list will lead those naturalists, who are favorably situated for examining these animals, to enlarge and perfect it.

I.—ECHINODERMATA.

Asterias.
spinosus, Say. *Sea-Star.* Whole coast.
Echinus.
granulatus, Say. *Sea-urchin.* do.
Scutella.
pentaphora. Beaches on the whole coast.

CLASS II.—ENTOZOA.

Filaria.
many species.
Tricocephalus.
dispar, Rudolphi: Inhabiting man.
Ascaris.
lumbricoides, Lin. do.
vermicularis, Lin. do.
mystax, Rud. Inhabiting the cat.
Strongylus.
gigas, Rud. Kidneys of the Mink, &c.
Planaria.
several species.
Tænia.
solium. } Tape Worm, in man.
tata. }
Tænia.
inhabiting the cat.
Cysterus.
cellulosæ, Gmel. On hogs, producing measles.
Cænurus.
cerebralis, Gmel. Brain of Sheep, producing the staggers.

CLASS III.—ACALEPHA.

Cyanea.

aurita, L. Sun fish—common.
one other Medusa.

CLASS IV.—CARNOSI.

Actinia.

marginata, Say. Nahant. *Sea anemone.*

Lucernaria.

one species. Northern coast.

CLASS V.—POLYPI.

Flustra.

one species, on sea weed, &c.

Corallina.

officinalis, attached to rocks shells, &c.

Spongia.

racemosa. Chelsea Beach.
fluviatilis, L. in ponds. Leverett, & Chesterfield.
one more, Boston Harbor.

CLASS VI.—INFUSORIA.

Vibrio.

glutinis, paste.
aceti, vinegar.
and numerous other species.

X.—CATALOGUE OF PLANTS,

GROWING WITHOUT CULTIVATION.

In the arrangement of the following Catalogue, I have followed,—as the latest and most accurate,—the Natural System of Prof. Lindley, as adapted to North American Plants by Prof. Torrey. The sources from which I have derived materials for constructing this list, are mainly the following; First, Professor Bigelow's 'Collection of Plants of Boston and its vicinity.' (1824.) Secondly, 'A Catalogue of Plants Growing without cultivation in the vicinity of Amherst College;' (1829,) with such additions and corrections as I have been able to make since the time of its publication. Thirdly, Professor Dewey's Catalogue of Plants found in the County of Berkshire, (1829,) inserted in the History of Berkshire. Fourthly, the manuscript communications of Thomas A. Greene Esq. containing a notice of such plants as he has discovered in the vicinity of New Bedford and on the Island of Nantucket, not mentioned in the last edition of Bigelow's 'Florula Bostoniensis.'

To the Latin or scientific names of the plants, I have attached their common names, whenever I could ascertain that they have excited attention enough to receive a common name. But it will be seen that comparatively few of our plants have received common names.

When a capital A. is attached to a species, it implies that the plant grows in the vicinity of Amherst: B. implies that it occurs in the vicinity of Boston: N. B. that it is found in the region around New Bedford: and B—e that Berkshire County is its place of growth. In other cases, especially where the species is very rare, the name of the town where it occurs is mentioned. When no local designation is annexed, I have reason to suppose that the plant may be found in any part of the State of considerable extent. In some of the flowerless plants, however, there is an exception to this remark; as will be mentioned under Muscoideae.

In reducing our plants to the Natural Orders I have received the assistance of Dr. John Blodget of Amherst.

ABBREVIATIONS.

? Indicates a doubt as to the species.
§ Prefixed to those plants that have been introduced or naturalized.

Names of Botanical Writers.

Ait.	for Aiton.
Brid.	— Bridel.
Big.	— Bigelow.
R. Br.	— R. Brown.
Bull.	— Bullard.
De. Cand.	— Decandolle.
Des.	— Desfontaines.
Dicks.	— Dickson.
Dill.	— Dillenius.
Ehrh.	— Ehrhart.
Ell.	— Elliott.
Fr.	— Fries.
Hall.	— Haller.
Hedw.	— Hedwig.
l'Herit.	— l'Heritier.
Hook.	— Hooker.
Hoffm.	— Hoffman.
Jacq.	— Jacquin.
Lamb.	— Lambert.
L.	— Linnæus.
Lind.	— Lindley.
Lmk.	— Lamarck.
Mx.	— Michaux.
Mx. f.	— Michaux filius.
Muhl.	— Muhlenberg.
Nutt.	— Nuttall.
P. de B.	— Palisot de Beauvois.
Pers.	— Persoon.
Ph.	— Pursh.
Raf.	— Rafinesque.
Rich.	— Richard.
Salis.	— Salisbury.
Schaeff.	— Schaeffer.
Schk.	— Schkuhr.
Schrad.	— Schrader.
Schreb.	— Schreber.
Schw.	— Schweinitz.
Sibth.	— Sibthorp.
Sm.	— Smith.
Spreng.	— Sprengel.
Sw.	— Swartz.
Tor.	— Torrey.
Tourn.	— Tournefort.
Vent.	— Ventenat.
Walt.	— Walter.
Wang.	— Wangenheim.
Web. & M.	— Weber & Mohr.
W.	— Willdenow.

CLASS I.—VASCULARES,

OR

FLOWERING PLANTS.

SUB CLASS I.—EXOGENÆ OR DICOTYLEDONS.

TRIBE I.—ANGIOSPERMÆ.

1 *Polypetalous, Apetalous, and Achlamydeous Plants.*

ARALIACEÆ.

Aralia, L.
hispida, Mx. *Bristly Stem Sarsaparilla.*
nudicaulis, L. *Wild Sarsaparilla.*
racemosa, L. *Spikenard.*
Panax, L.
quinquefolium, L. *Ginseng.* A.
trifolium, L. *Dwarf Ground Nut.*

UMBELLIFERÆ.

Æthusa, L.
§ cynapium, L. *Fool's Parsley.* Boston.
Angelica, L.
atropurpurea, L. *triquinata, Big. Angelica.*
Cicuta, L.
bulbifera, L. *Bulbiferous Cicuta.*
maculata, L. *American Hemlock.*
Conium, L.
maculatum, L. *Poison Hemlock*
crantzia, Nutt.
Crantzia, Nutt.
lineata, Nutt. Near Boston: found by Mr. Nuttall. B. D. Greene Esq.
Cryptotænia, De Cand.
Canadensis, De Cand. *Sison, L. Chaerophyllum, Pers. Hone Wort. Mock* [*Sanicle.*
Daucus, L.
§carota, L. *Carrot.* B—e.
Discopleura, De Cand.
capillacea, De. Cand. *Ammi capillaceum, Spreng. Bishop-Weed.* N. B.
Heracleum, L.
lanatum, Mx. *Cow Parsnip.*
Hydrocotyle, L.
Americana, L.
umbellata, L. B.
vulgaris, Mx. N. B.
Ligusticum, L.
scoticum, L. B. *Sea Lovage.*
Osmorhiza, Raf *Uraspermum, Nutt. Scandix, Muhl.*
longistylis, De Cand.
brevistylis, De Cand. *Sweet Cicely.*

- Pastinaca, L. *Parsnip.*
  - § sativa, L.
- Sanicula, L.
  - Marilandica, L. *Sanicle.*
- Sium, L.
  - latifolium, L. *Water Parsnip.*
  - lineare, Mx.
- Smyrnium, L.
  - aureum, L. *Sison aureus, Spreng. Thaspium aureum, Nutt. Meadow [Parsnip. A.*

RANUNCULACEÆ.

- Actæa, L.
  - alba, Big.
  - racemosa, L. *Cimicifuga serpentaria, Ph. Black Snake Root.* B—e
  - rubra, Willd. *Bane-berry.* [Mr. M. A. Curtis.
- Anemone, L.
  - nemorosa, De Cand. *Low Anemone.*
  - thalictroides, L. *Rue Anemone. Thalictrum anemonoides. Mx.*
  - Virginiana, L. *Wind-Flower.*
- Aquilegia, L.
  - Canadensis, L. *Columbine.*
- Atragene, L.
  - Americana, Sims. *Atragene. Clematis verticillaris, De Cand.*
- Caltha, L.
  - palustris, L. *Cowslip.*
- Clematis, L.
  - Virginiana, L. *Virgin's Bower.*
- Coptis, Salisbury.
  - trifolia, Salis. *Gold Thread.*
- Hepatica, W.
  - triloba, W. *Liverwort.*
- Ranunculus, L.
  - abortivus, L.
  - acris, L. *Buttercup.*
  - bulbosus, L.
  - cymbalaria, Ph.
  - fascicularis, Muhl.
  - filiformis, Mx. *reptans, L.*
  - flammula, L. *Spear Wort.*
  - fluvitalis, W. *River Crowfoot.*
  - hirsutus, Curtis, B—e.
  - multifidus, Ph. B.
  - Pennsylvanicus, L. B.
  - recurvatus, Ph.
  - repens, L.
  - sceleratus, L. *Celery Crowfoot.*
- Thalictrum, L.
  - dioicum, L. *Meadow Rue.*
  - cornuti, Hooker, *pubescens Ph. revolutum, De. Cand.*

PAPAVERACEÆ.

- Chelidonum, L.
  - majus, W. *Celandine.*
- Sanguinaria, L.
  - Canadensis, L. *Blood Root.*

NYMPHÆACEÆ.

- Nymphæa, L.
  - odorata. Ait. *White Pond Lily.*

- Nuphar, Sm.
  - advena, Ait. *Yellow Water Lily.*
  - kalmiana, Ait.

HYDROPELTIDEÆ.

- Hydropeltis, Mx.
  - purpurea, Mx. *Water Shield.*

PODOPHYLLEÆ.

- Podophyllum, L.
  - peltatum, L. *May Apple.*

CRUCIFERÆ.

- Arabis, L.
  - falcata, Mx. *Canadensis*, L.
  - hastata, L. *Hairy Tower Mustard.*
  - hirsuta, Smith. *Turritis hirsuta, Jacq.*
  - rhomboidea, Ph. B. *Cardamine rhomboidea, De Cand.*
  - thaliana, L, *Spring Cress.* B—e.
- Barbarea, R. Brown.
  - vulgaris, R. Br. *Erysimum barbarea*, L. *Water Radish.*
- Brassica, L.
  - § napus, L. *Kale.*
- Cakile, L.
  - Americana, Nutt. *Bunias maritima, Ph.* B. *Am. Sea Rocket.*
- Cardamine, L.
  - Pennsylvanica, W. *Water Cress.*
  - Virginica, W. B—e.
  - teres ? Mx. A. Dr. G. White.
- Cochlearia, L.
  - § armoracea, L. *Horse Radish.*
- Dentaria, L.
  - diphylla, Mx. *Tooth Root.* A.
  - laciniata, A. Muhl.
- Draba, L.
  - arabizans, Mx. B—e.
- Erophila, De Cand.
  - vulgaris, De Cand. *Draba verna. Ph. Whitlow Grass.*
- Lepidium, L.
  - Virginicum, L. *Wild Peppergrass.*
- Nasturtium, Brown.
  - amphibium, Brown. *Sisymbrium amphibium, L. Water Radish.*
  - officinale, Brown. *Sisymbrium nasturtium, L. English Water Cress.*
- Raphanus, L.
  - § raphanistrum, L. *Cadlock, Wild Radish.*
- Sinapis, L.
  - § nigra. *Mustard*, L.
- Sisymbrium, Allioni.
  - officinale, De Cand. *Erysimum officinale, L. Hedge Mustard.*
- Thalspi, L.
  - bursa-pastoris, L. *Shepherd's Purse.*
  - campestris, L. *Yellowseed.*

FUMARIACEÆ.

- Corydalis Vent.
  - fungosa, Pers. *Adlumia cirrhosa, Raf. Climbing Colic Weed.*
  - glauca, Ph.
- Diclytra, De Cand.
  - cucullaria, De Cand. *Corydalis cucullaria, Pers. Colic Weed.*
  - formosa, De Cand. A. *Corydalis formosa, Ph.*

Fumaria, L.
    § officinalis, L. *Fumitory.*

MAGNOLIACEÆ.

Liriodendron, L.
    tulipifera, L. *Tulip Tree.* A. and N. B.

Magnolia, L.
    glauca, L. *Beaver Tree. Swamp Laurel. Gloucester.*

LAURINEÆ.

Laurus, L.
    benzoin, L. *Spice Bush. Fever Bush.*
    sassafras, L. *Sassafras.*

BERBERIDEÆ.

Berberis, L.
    vulgaris. L. *Barberry. L.*

Leontice, L.
    thalictroides, L. *Caulophyllum thalictroides, Mx. Poppose Root. Cohosh.*

MENISPERMEÆ.

Menispermum, L.
    Canadense, L. *Moonseed.* A.

MALVACEÆ.

Althæa, L.
    officinalis, L. *Marsh Mallows.* B. and N. B.

Hibiscus, L.
    palustris, L. B. *Marsh Hibiscus.*

Malva, L.
    rotundifolia, L. *Low Mallows.*
    § sylvestris. L. *High Mallows.*

Sida, L.
    abutilon, L, *Indian Mallows.* A.

TILIACEÆ.

Tilia, L.
    glabra, Vent. *Bass Wood.*
    pubescens, Ait. *Americana, Walt, Bass Wood.*

HYPERICINEÆ.

Hypericum, L.
    angulosum, Mx.
    ascyroides, W. *Saint John's Wort.*
    Canadense, L.
    corymbosum, W.
    cystifolium, Lmk. A.
    parviflorum, W.
    perforatum, L. *Saint John's Wort.*
    sarothra, Mx. *Sarothra gentianoides, W.*
    Virginicum, L. *Elodea campanulata, Ph.*

SAXIFRAGEÆ.

Chrysosplenium, L.
    Americanum, Hooker. *oppositifolium, L. Golden Saxifrage.*

Mitella, L.
    cordifolia, L. B—e.
    diphylla, L. *Currant Berry.* A.

Parnassia, L.
    Caroliniana, Mx. *Parnassus Grass.*

Saxifraga, L.
    Pennsylvanica, L. *Water Saxifrage.*
    Virginiensis, Mx. *Rock Saxifrage.*

- Tiarella, L.
  - cordifolia, L. *Mitre Wort.*

HAMAMELIDEÆ.

- Hamamelis, L.
  - Virginica, L. *Witch Hazel.*

GROSSULACEÆ.

- Ribes, L.
  - cynobasti, Jacq. B—e. *Wild Gooseberry.*
  - gracile, Mx. A.
  - floridum, l'Herit. *Black Currant.*
  - lacustre, Ph. A. & B—e. *Gooseberry.*
  - prostratum, L Herit. A.
  - rigens, Mx. B. & A.
  - triflorum, W. *Wild Gooseberry.*
  - trifidum, Mx. B—e.

CACTEÆ.

- Cactus, L.
  - opuntia, L. Nantucket T. A. Greene. *Opuntia vulgaris, De Cand.* [*Prickly Pear.*

ONAGRARIÆ.

- Epilobium, L.
  - coloratum, Muhl.
  - lineare, Muhl. *rosmarinifolium, Ph.*
  - molle, Torrey. A.
  - palustre, L. B—e.
  - spicatum, Lam. *Willow Herb.*
- Isnardia, L.
  - palustris, L. *Water Purslane.*
  - alternifolia, De Cand. *Ludwigia alternifolia, L. Seed Box.*
- Œnothera, L.
  - biennis, L. *Scabish. Tree Primrose.*
  - chrysantha, Mx. B—e. *var. of Œ. pumila ?*
  - fruticosa, L. Plymouth. T. A. Greene.
  - pumila, L.

HALORAGEÆ.

- Myriophyllum, L.
  - ambiguum, Nuttall. N. B.
  - procumbens, Big. Danvers.
  - spicatum, L. B.
- Myriophyllum.
  - tenellum, Big. Tewksbury and Plainfield.
  - verticillatum, L. *Water Milfoil.*
- Proserpinaca, L.
  - palustris, L. *Mermaid Weed.*
  - pectinacea, Lam. N. B.

CIRCÆACEÆ.

- Circæa, L.
  - alpina, L. *Enchanter's Night Shade.*
  - lutetiana, L. *Canadensis, Muhl.*

LOASEÆ.

- Centaurella, Mx.
  - paniculata, Mx. *Bartonia paniculata, Muhl. Screw Stem.*

SALICARIÆ.

- Ammannia, L.
  - humilis, Mx. B.
- Cuphea, Jacq.
  - vicosisima, Jacq. Pittsfield. Dr. G. White.

Lythrum, L.
hyssopifolium, L. B.
salicaria, Ph. N. B.
verticillatum, L. *Decodon verticillatum, Ell. Swamp willow Herb.*

MELASTOMACEÆ.

Rhexia, Brown.
Virginica, L. *Meadow Beauty. Deer Grass.*

ARISTOLOCHIÆ.

Asarum, L.
Canadense, L. *Wild Ginger.*

SANTALACEÆ.

Nyssa, L.
biflora, Walt. *Sour Gum.* A. and Plymouth. T. A Greene.
villosa, Mx. *Sour or Black Gum.*
Thesium, L.
umbellatum, L. *False Toad Flax.*

THYMELEÆ.

Dirca, L.
palustris, L. *Moose Wood. Leather Wood.*

SANGUISORBEÆ.

Sanguisorba, L.
Canadensis, L. *Burnet Saxifrage.* A. & B.

ROSACEÆ.

Agrimonia, L.
eupatoria, L. *Agrimony.*
Amelanchier, De Cand.
botryapium, De Cand. *Aronia botryapium, L.*
ovalis, De Cand. *Aro. ovalis, Pers.*
sanguinea, De Cand. *Pyrus. sang. Ph.* Western part of the State? Big.
Comaropsis, Rich.
fragrarioides, De Cand. B—e and A. *Dalibarda fragrarioides, Mx.*
Dalibarda, L.
repens, Lmk. Greenfield and Princeton.
Fragraria, Tourn.
Virginiana, L. *Strawberry.*
Geum, L.
rivale, L. *Purple Avens.*
strictum, Ait. *Upright Avens.*
Virginianum, L. *Avens.*
Potentilla, L.
anserina, L. B.
argentea, L. *Silver Five Finger.*
Canadensis, L. *Five Finger.*
confertiflora, Torrey. *Bootia sylvestris, Big. Geum argrimonoides,* [*Ph.*
fruticosa, L.
norwegica, L. *Cinquefoil.*
palustris, Scop. *Comarum palustre, L.* B-e & B.
simplex, Mx. B.
tridentata, Ait. Hoosic Mountain & Wachusett.

- Rosa, L.
  - corymbosa, Ehrh. *Carolina, L. Swamp Rose.*
  - lucida, Ehrh. B—e.
  - micrantha, Sm. B.
  - parviflora, Ehrh. *Caroliniana, Mx.*
  - § rubiginosa, L. *Sweet Briar.*
- Rubus, L.
  - Canadensis, L.
  - frondosus. Big. B.
  - obovalis, L.
  - occidentalis, L. *Black Raspberry.*
  - odoratus. L. *Flowering Raspberry.*
  - setosus, Big. B.
  - strigosus, Mx. *Red Raspberry.*
  - saxatilis, Mx. *Stone Raspberry.* B.
  - trivalis, Mx. *sempervirens, Big ? Dewberry.*
  - villosus, Ait. *Blackberry.*
- Spiræa, L.
  - salicifolia, Mx. *Hard Hack.*
  - tomentosa, L. *Steeple Bush.*

POMACEÆ.

- Cratægus, L.
  - coccinea, L. *Thorn Bush.*
  - crusgalli, Ait. B. *Thorn Bush.*
  - punctata, Jacq. *Thorn Bush.*
- Pyrus, L. *Aronia, Pers.*
  - Americana, De Cand. *Sorbus Americana. Ph. Mountain Ash.*
  - arbutifolia, Var. melanocarpa. Tor.

AMYGDALEÆ.

- Cerassus, Juss. *Prunus, L.*
  - borealis, Mx. *P. borealis, Ph. Choke Cherry.*
  - Canadensis, De Cand. *P. Canadensis, W.*
  - depressa, De Cand. *P. depressa, Ph. Sand Cherry.*
  - pubescens, De Cand. *P. littoralis, Big.*
  - pumila, Mx. *P. pumila, Lam.*
  - serotina, De Cand. *P. serotina, Ph. non W. obovata, Big. Choke Cherry.*
  - Virginiana, Mx. *P. Virg. L. Wild Cherry.*
- Prunus, L.
  - Americana, Marshall. *Wild Plum.* A.
  - mollis, Tor. B—e.

LEGUMINOSEÆ.

- Amphicarpa, De Cand.
  - monoica, Ell. *Glycine Pea Vine. monoica, L.*
- Apios, Ph.
  - tuberosa, Moench. *Ground Nut, Glycine apios, L.*
- Baptisia, Vent.
  - tinctoria, R. Brown. *Wild Indigo.*
- Cassia, L.
  - chamæcrista, L. *Partridge Pea.*
  - Marilandica, L. *Wild Senna.*
  - nictitans, L. Hadley, Springfield, and N.B.
- Crotolaria, L.
  - sagittalis, L. *Rattle Box.*
- Genista, Lam.
  - tinctoria, L. *Dyer's Weed.* B.

- Hedysarum, L. *Desmodium, De Cand.*
  - acuminatum, Mx.
  - bracteosum, Mx.
  - Canadense, L. *Bush Trefoil.*
  - ciliare, Nutt. B—e.
  - cuspidatum ? W. B.
  - humifusum, Muhl.
  - nudiflorum, L.
  - obtusum, Muhl. A. and N. B.
  - paniculatum, L.
  - rotundifolium, Mx.
  - viridiflorum, L.
- Lathyrus, L.
  - palustris, L. B.
- Lespedeza, Mx.
  - angustifolia, Ell. Plymouth, T. A. Greene.
  - capitata, Mx.
  - polystachia, Mx.
  - procumbens, Mx.
  - prostrata, Ph. B.
  - reticulata, Pers.
  - sessiliflora, Nutt.
  - violacea, Pers.
- Lupinus, L.
  - perennis, L. *Wild Lupine.*
- Medicago, L.
  - lupulina, L. B.
- Phaseolus, L.
  - trilobus, Mx. B. *Bean Vine.*
- Pisum, L.
  - maritium, L. *Sea Pea.* B. *Lathyrus maritimus, Big.*
- Robinia, L.
  - pseudacacia, L. *Locust Tree.*
- Tephrosia, L.
  - Virginiana, Pers. *Galega virginiana, L. Pers. Goat's Rue.*
- Trifolium, L.
  - agrarium, L. Cummington.
  - arvense, L. *Field Clover.*
  - officinale, L. *Melilotus officinalis; W. Melilot.*
  - pratense, L. *Red Clover.*
  - procumbens, L.
  - repens, L. *White Clover.*
- Vicia, L.
  - cracca, L. *Vetch.*
  - pusilla, Muhl. B. *Ervum tetraspermum, L.*
  - sativa, L. *Tare.*

URTICEÆ.

- Bœhmeria, W.
  - cylindrica, W. *False Nettle.*
- Humulus, L.
  - lupulus, L. *Hop.*
- Parietaria, L.
  - Pennsylvanica, Muhl. Sugar loaf, Deerfield.
- Urtica, L.
  - Canadensis, L. *Yellow Nettle.* A.
  - dioica, L. *Common Nettle.*

Urtica, L.
procera, Muhl. B—e.
pumila, L. *Stingless Nettle.*
urens, L. *Dwarf Stinger.*

ULMACEÆ.

Celtis, L.
occidentalis, L. *Nettle Tree.* Deerfield and Waltham.
Ulmus, L.
Americana, L. *Elm.*
fulva, Mx. *Slippery Elm.*

ARTOCARPEÆ.

Morus, L.
§ alba, L. *White Mulberry.*
rubra, L. *Red Mulberry.* Deerfield ?

CUPULIFERÆ.

Castanea, Tourn.
Americana, Mx. *Chesnut.*
Corylus, L.
Americana, Walt. *Hazel Nut.*
rostrata, Ait. *Beaked Hazel Nut.*
Fagus, L.
ferruginea, Ait. *Beech Tree.*
Quercus, L.
alba, L. *White Oak.*
bicolor, W.
ambigua ? Mx. et fil.
banisteri, Mx. *Shrub Oak.*
coccinea, Wang. *Scarlet Oak.*
montana, W. *Chesnut Oak.*
palustris, W. *Pin Oak.* A.
prinos-chinchapin, Mx. A. *Chinquapin.* 2 to 6 feet high.
prinos-discolor, Mx. *Swamp White Oak.*
rubra, L. *Red Oak.*
tinctoria, Mx. *Black Oak.*

BETULINEÆ.

Alnus, W.
glutinosa, L. A.
serrulata, Willd. *Alder.*
Betula, L.
excelsa, Ait. *Yellow Birch.*
glandulosa, Mx. B—e. *Shrub Birch.*
lenta, L. *Black Birch.*
papyracea, Ait. *Canoe Birch.*
populifolia, Ait. *White Birch.*
pumila, L.
rubra, Mx. & fil. *nigra, L. Red Birch.* B—e.
Carpinus, L.
Americana, W. *Horn Beam.*
Ostrya, Mx.
Virginica, W. *Iron Wood. Hop Hornbeam.*

SALICINEÆ.

Populus, L.
balsamifera, L. *Balsam Poplar.*
candicans, Ait. *Balm of Gilead.*
§ dilatata, L. *Lombardy Poplar.*

- Populus, L.
  - grandidentata, Mx. *Poplar.*
  - tremuloides, Mx. *White Poplar.*
- Salix, L. *Willow.*
  - § Babylonica, L.
  - conifera, Wang.
  - cordata, Muhl.
  - discolor, Willd. B. *Bog Willow.*
  - eriocephala, Mx. *Swamp Willow.* B.
  - falcata, Ph.
  - grisea, W.
  - lucida, Muhl.
  - Muhlenbergiana, W.
  - myricoides, Muhl.
  - nigra, Marsh.
  - pedicellaris, Ph.
  - prinoides, Ph. B—e.
  - rigida, Muhl.
  - tristis, Muhl. B—e.
  - vitellina, L. *Yellow Willow.*
  - viminalis, L. *Osier Basket Willow.* B.

PLATANEÆ.

- Platanus, L.
  - occidentalis, L. *Sycamore. Button-Wood.*

MYRICEÆ.

- Comptonia, Gaert.
  - asplenifolia, Ait. *Sweet Fern.*
- Myrica, L.
  - cerifera, L. *Bay Berry.*
  - gale, L. *Sweet Gale.*

JUGLANDEÆ.

- Carya, Nutt.
  - alba, Nutt. *Juglans squamosa, Mx. Common Hickory.*
  - amara, Nutt. *J. amara, Mx. Bitter Nut.* Deerfield and Sheffield.
  - porcina, Nutt. *J. porcina, Mx. Pig Nut.*
- Juglans, L.
  - cinerea, L. *Butternut.*
  - § nigra, L. *Black Walnut.*

EUPHORBIACEÆ.

- Acalypha, L.
  - Virginica, L. *Three seeded Mercury.*
- Euphorbia, L.
  - maculata, L. *Spotted Spurge.*
  - helioscopia, L. B.
  - hypericifolia, L.
  - polygonifolia, L. B.

CELASTRINEÆ.

- Celastrus, L.
  - scandens, L. *False Bitter Sweet.*

RHAMNEÆ.

- Ceanothus, L.
  - Americanus, L. *New Jersey Tea.*
- Rhamnus, L.
  - alnifolius, l'Herit. *Dwarf Alder.* Deerfield.
  - § catharticus, L. *Buckthorn.*

STAPHYLEACEÆ.

Staphylea, L.
trifolia, L. *Baldder Nut.* Mt. Holyoke, Deerfield, and Weston.

ACERINEÆ.

Acer, L.
dasycarpum, W. *eriocarpum, Mx. Silver Maple.*
Pennsylvanicum, L. *striatum, Mx. Striped Maple. Moose-Wood.*
rubrum, L. *Red Maple.*
saccharinum, L. *Sugar Maple.*
spicatum, L. *montarium, Ait. Mountain Maple Bush.*

VITES.

Ampelopsis, Mx.
quinquefolia, Mx. *Cissus hederacea Pers. False Grape. Five finger.*
Vitis, L.
æstivalis, Mx. *intermedia, Muhl Summer Grape.*
cordifolia, Mx. *vulpina L. Frost Grape.*
labrusca, L. *Plum Grape. Fox Grape.*

ANACARDIACEÆ.

Rhus, L.
aromatica, Ait. *Fetid Sumach.* B—e.
copallina, L. *Sumach.*
glabra, L. *Sumach.*
radicans, L. *Poison Ivy.*
toxicodendron, L. *Poison Ivy.*
typhina, L. *Sumach.*
venenata, De Cand. *vernix* L. *Poison Sumach. Dog Wood.*

XANTHOXYLEÆ.

Xanthoxylum, L.
fraxineum, W. *Prickly Ash.*

GERANIACEÆ.

Geranium, L.
dissectum, Willd. B.
maculatum, L. *Crow-Foot Geranium.*
robertianum, L. *Herb Robert.*

OXALIDEÆ.

Oxalis, L.
acetosella, L. *Wood Sorrel.*
stricta, L. *Yellow Wood Sorrel.*
violacea, L. *Violet Wood Sorrel.*

BALSAMINEÆ.

Impatiens, L.
fulva, Nutt. *biflora, Ph. Jewel Weed.*
pallida, Nutt. *noli tangere, Ph. Touch-me-not.*

POLYGALEÆ.

Polygala, L.
cruciata. L. B.
paucifolia, W. *Flowering Wintergreen.*
polygama, Walt. *rubella, Muhl.*
sanguinea, L.
verticillata, L. *Dwarf Snake Root.*

VIOLACEÆ.

Viola, L.
acuta, Big. B and A.
blanda, W. *Smooth Violet.*
Canadensis, L. *Woods Violet.*
cucullata, Ait. *Common Violet.*
Muhlenbergii, Tor. *debilis,* Ph. *Spear Violet. B.*

- Viola, L.
  - lanceolata, L.
  - obliqua ? Schwein. *Weak Stem Violet.*
  - striata, Ait. *ochroleuca, Schwein.* Amherst.
  - ovata, Nutt.
  - palmata, L. *Hand Violet.*
  - pedata, L. *Bird foot Violet.*
  - pubescens, Ait. *Yellow Violet.*
  - rostrata, Muhl. *Beaked Violet.*
  - rotundifolia, Mx. *Ground Violet.*
  - sagittata, Ait. *Arrow Violet.*
  - § tricolor, L. *Garden Violet.*
  - villosa, Walt.

CISTINEÆ.

- Helianthemum, Tourn. *Cistus, L.*
  - Canadense, Mx. *Rock Rose.*
  - ramuliflorum, Mx. N. B.
- Hudsonia, L.
  - ericoides, L. *False Heath.* Cape Cod and Nantucket.
  - tomentosa, Nutt. B. *Poverty Grass.* Cape Cod and Nantucket.
- Lechea, L.
  - major, L. *Pin Weed.*
  - minor, L. Do.
  - racemulosa, Mx. *Clustered Pin Weed.*

SARRACENIÆ.

- Sarracenia, L.
  - purpurea, L. *Sidesaddle Flower.*

DROSERACEÆ.

- Drosera, L.
  - longifolia, L.
  - rotundifolia, L. *Sun Dew.*
  - tenuifolia, Muhl. B.

LINEÆ.

- Linum, L.
  - Virginianum, L. *Wild Flax.*

CARYOPHYLLEÆ.

- Agrostemma, L.
  - githago. L. *Cockle.*
- Arenaria, L.
  - lateriflora, L. *Sand Wort.* Springfield.
  - marina, Sm. *Canadensis, Pers.* B.
  - peploides, L. B.
  - rubra, L. B. & A.
  - § serpyllifolia, L.
- Cerastium, L.
  - § arvense, L.
  - hirsutum, Muhl. A ? *connatum, Beck.*
  - oblongifolium, Torrey.
  - § semidecandrum, L.
  - tenuifolium, Ph.
  - § viscosum, L.
  - vulgatum, L. *Chickweed:*
- Cucubalus, L.
  - behen, L.
  - stellatus, L. B. *Star Campion.*

Dianthus, L.
armeria, L. *Pink*, B. and Banks of Ct. River near Mt. Tom.
Mollugo, L.
verticillata, L. *Carpet Weed.*
Sagina, L.
procumbens, L. *Pearl Wort.*
Saponaria, L.
§ officinalis, L. *Bouncing Bet.* Soap Wort.
vaccaria, L. *Field Soap Wort.* Williamstown.
Silene, L.
antirrhina, L. *Sleepy catch Fly. Snap Dragon.*
Pennsylvanica, Mx. *Pink Catch Fly.*
Spergula, L.
arvensis, L. *Spurry.*
Stellaria, L.
lanceolata, Torrey.
longifolia, Muhl. *Longleafed Starwort.*
media, Smith. *Alsine media, L. Chickweed.*

PORTULACEÆ.

Claytonia, L.
Virginica, L. *Spring Beauty.*
Portulacca, L.
oleracea, L. *Purslane.*

CRASSULACEÆ.

Penthorum, L.
sedoides, L. *Virginian Orpine.*

ILLECEBREÆ.

Queria, L.
Canadensis, L. *Anychia dichotoma, Mx. Fork Chickweed.*

AMARANTHACEÆ.

Amaranthus, L.
§ blitum. Willd. B.
hybridus, L.
§ oleraceus, L? *Pot Amaranth.*
pumilus, Nutt. Nashawn Island. T. A. Greene.
retroflexus, L. B. B—e. Mr. M. A. Curtis.

SCLERANTHEÆ.

Scleranthus, L.
annuus, L. *Gravel Chickweed.*

CHENOPODEÆ.

Acnida, L.
cannabina, L. *Water Hemp*, B.
Atriplex, L.
arenaria, Nutt. N. B.
patula, L. B.
Blitum, L.
capitatum, L. *Strawberry Blite.*
Chenopodium, L.
§ album, L. *Pigweed. Hogweed.*
§ botrys, L. *Oak of Jerusalem.*
§ hybridum, L. *Tall Goosefoot.*
rhombifolium, Muhl. B. Mr. M. A. Curtis.
rubrum, L. *Rusty Pigweed, Red Goosefoot.*
Salicornia, L.
herbacea, L. *Samphire. Glass Wort.* B.

Salicornia, L.
mucronata, Big. B.
ambigua, Mx. N. B.

Salsola, L.
Carolinia. Mx, B.
salsa, Mx. B.

PHYTOLACCEÆ.

Phytolacca, L.
decandra, L. *Poke weed.*

POLYGONEÆ.

Polygonum, L.
amphibium, L.
arifolium, L. *Knotweed.*
articulatum, L.
aviculare, L. *Joint Weed.*
cilinode, Mx.
coccineum, W. B.
convolvulus, L. *Bind Knotweed.*
§ fagopyrum, L. *Buck Wheat.*
lapathifolium, L. A.
mite, Pers. *Tasteless Knotweed.*
§ orientale, L. *Princes Feathers.*
persicaria, L. *Heart's Ease.*
Pennsylvanicum, N. B.
punctatum, Ell. *Biting Knotweed.*
sagittatum, L. *Prickly Knotweed.*
scandens, L. *Climbing Buck wheat.*
tenue, Mx. *Slender Knot Grass.*
Virginianum, L.

Rumex, L.
acetosella, L. *Field Sorrel.*
acutus ? L.
Brittanicus, L. B.
crispus, L. *Dock.*
obtusifolius, L. *Broad Leaved Dock.*
pallidus, Big. B.

PODOSTOMEÆ.

Podostemum, Mx.
ceratophyllum, Mx. *Thread Foot. A.*

CALLITRICHINEÆ.

Callitriche, L.
linearis, Ph. A. & N. B.
verna, Muhl.

CERATOPHYLLEÆ.

Ceratophyllum, L.
demersum, L. Nantucket. *Hornwort.*

II.—Monopetalous Plants.

ILICINEÆ.

Ilex, L.
Canadensis, Mx. *Nemopanthes Canadensis, De Cand. Mountain Holly.*
opaca, Ait. *Evergreen Holly. B.*

Prinos, L.
ambiguus, Mx. B.
glaber, L. B.
verticillatus, L. *Winter Berry. Black Alder.*

ERICEÆ.

- Andromeda, L.
    - calyculata, L. *Leather Leaf.*
    - ligustrina, Muhl. *White Bush.*
    - paniculata, Mx. B.
    - polifolia, L. A.
    - racemosa, Mx. B.
- Arbutus, L.
    - uva ursi, L. *Bear Berry.*
- Azalea, L.
    - nudiflora, L. *Rhododendron nudiflorum, Tor. Honey Suckle.*
    - viscosa, S. *R. viscosa, Torrey. White Honey Suckle.*
- Clethra, L.
    - alnifolia, L. *Spiked Alder. B. and Worcester.*
- Epigæa, L.
    - repens, L. *Trailing Arbutus.*
- Gaultheria, L.
    - procumbens, L. *Partridge Berry.*
- Kalmia, L.
    - angustifolia, L. *Sheep Laurel.*
    - glauca, Ait. *Swamp Laurel.*
    - latifolia. L. *Laurel.*
- Lasicopa, Torrey, MS.
    - hispidula, Tor. *Gaultheria hispidula, Muhl.*
- Ledum, L.
    - latifolium, Ait. *Labrador Tea. Amherst.*
- Rhododendron, L.
    - maximum, L. *American Rose Bay. Medfield & Dedham.*
- Rhodora, L.
    - Canadensis, L. *False Honeysuckle. A. and B.*

VACCINEÆ.

- Oxycoccus, Pers.
    - macrocarpus, Ph. *Cranberry.*
    - vulgaris ? Ph. *Cranberry.*
- Vaccinium, L.
    - corymbosum, L. *Giant or Swamp Whortleberry.*
    - frondosum, L. *Blue Whortleberry.*
    - hirtellum, Ait. B.
    - Pennsylvanicum, Lam. *Black-blue Whortleberry.*
    - resinosum, Ait. *Black Whortleberry.*
    - stamineum, L. *Squaw or Green Whortleberry. Deer Berry.*
    - tenellum, Ait. B.
    - virgatum, Muhl. B.
    - vitis-idea, L. Lynn.

PYROLACEÆ.

- Monotropa, L.
    - languinosa, Mx. *Hypopithys lanuginosa, Nutt. Pine Sap.*
    - uniflora, L. *Bird's Nest. Tobacco Pipe.*
- Pyrola, L.
    - asarifolia, Mx. *Winter Green.*
    - elliptica, Nutt.
    - maculata, L. *Chimaphila, Ph. Spotted Winter Green.*
    - rotundifolia, L. *Shin-leaf Wintergreen.*
    - secunda, L. *One-sided Wintergreen.*
    - umbellata, L. *Chimaphila, Ph. Pipsissawa. Prince's Pine. Wintergreen.*
    - uniflora, L. Lynn, Mr. Oakes.

CAMPANULACEÆ.

Campanula, L.
aparinoides, Ph. *Prickly Bell Flower.*
perfoliata, L. *Amplexicaulis, Mx. Clasping Bell Flower.*
rotundifolia, L. *Hair Bell, A.*

LOBELIACEÆ.

Lobelia, L.
cardinalis, L. *Cardinal Flower.*
dortmanna, L. A. and B.
inflata L. *Wild Tobacco.*
kalmii, L. A. and B.
Nuttallii? R. and S. Ludlow and Springfield.
pallida, Muhl.
syphilitica, L. B—e.

CUCURBITACEÆ.

Mormordica, L.
echinata, Muhl. Hadley and Deerfield.
Sicyos, L.
angulata, L. *Single Seed Cucumber. A.*

PLANTAGINEÆ.

Plantago, P.
lanceolata, L. *Rib Wort.*
major, L. *Plantain.*
maritima, L. B. *Sea Plantain.*

PLUMBAGINEÆ.

Statice, L.
limonium, L. *Marsh Rosemary.* B.

DIPSACEÆ.

Dipsacus, L.
§ sylvestris, L. *Wild Teasel.* Sheffield.

COMPOSITÆ.

Achillea, L.
millefolium, L. *Yarrow.*
Agathyrnus, Don.
leucophæus, Don. *Sonchus leucophæus, W. Sow Thistle.*
Ambrosia, L.
elatior, L. *Hog Weed. Anakim.*
heterophylla, Muhl. B.
trifida, L. *Wild Wormwood.*
Anthemis, L.
cotula, L. *May Weed.*
Apargia, W.
autumnalis W. *Oporinia autumnale, Don. False Hawkweed.* B.
Arctium, L.
lappa, L. *Burdock.*
Artemesia, L.
Canadensis, Mx. *Wild Wormwood.* A. and B.
§ vulgaris, L. *Garden Wormwood.* Naturalized on the hilly parts of the State.
Aster, L.
acuminatus, Mx.
amplexicaulis, Mx. B.
amygdalinus, Mx. *umbellatus, Ait.*
conyzoides, W.
cordifolius, L.
cornifolius, Muhl. B.
corymbosus, Ait.

- Aster, L.
  - cyaneus, Hoff.
  - diversifolius, Mx.
  - dumosus, L.
  - ericoides, N. B.
  - lævis, Willd. B.
  - linariifolius, W.
  - macrophyllus, Ait.
  - miser, L. *a* divergens ; *b* diffusus.
  - multiflorus, W.
  - mutabilis, W. B.
  - Novi-Angliæ, L.
  - Novæ-Belgii, L.
  - paniculatus, Ait. B—e.
  - phlogifolius, W. B—e.
  - prenanthoides, W. B—e.
  - puniceus, L.
  - rigidus, W. A.
  - salicifolius, W.
  - solidaginoides, W.
  - sparsiflorus, Mx. N. B.
  - spectabilis, Ait. N. B.
  - tradescanti, W.
  - subulatus, Mx. Marshfield and B.
  - umbellatus, Ait. B.
- Bidens, L.
  - cernua, L. N. B.
  - chrysanthemoides, W. *Daisy Beggar Ticks.*
  - connata, W. A.
  - frondosa, L. *Burr Marygold.*
  - tripartita, L. B.
- Carduus, L. *Cnicus, W.*
  - altissimus, L.
  - arvensis, L. *Canada Thistle,*
  - discolor, Nutt. *Common Thistle.*
  - lanceolatus, L. *Common Thistle.*
  - glutinosus, Beck. B. *Cnicus glutinosus, Big.*
  - spinosisimus, Walt. { *Cnicus horridulus, Ph.*
  - pumilus, Nutt. B.
- Centaurea, L.
  - § nigra, L. B. Hardwick & Bristol, R. I.
- Chrysanthemum, L.
  - leucanthemum, L. *Ox-eyed Daisy.*
- Cichorium, L.
  - intibus, L. *Succory.*
- Conyza, L.
  - camphorata, Ph. *C. Marilandica, Mx. Marsh Flea Bane.*
- Coreopsis, L.
  - trichosperma, Mx. B.
  - rosea, Nutt. Plymouth. T. A. Greene.
- Erigeron, L.
  - bellidifolium, L.
  - Canadense, L.
  - heterophyllum, L.
  - integrifolium, Big. B.
  - Philadelphicum, L.
  - purpureum, L.
  - strigosum, L

Eupatorium, L.
ageratoides, W.
aromaticum, W. B.
hyssopifolium, L. N. B.
maculatum, L. B—e.
ovatum, Big. B.
perfoliatum, L. *Thorough Wort.*
pubescens, Willd. B.
purpureum, L. *Joe Pye.*
sessilifolium, L.
teucrifolium, L. *verbenæfolium, Mx.*
verticillatum, W. *Joe Pye Weed.*
Gnaphalium L.
decurrens, Ives.
Germanicum, Sm. N. B.
margaritaceum, L. *Life Everlasting.*
plantagineum, L. *Do.*
polycephalum, Mx. *Sweet scented do.*
purpureum, A. L.
uliginosum, L.
Helianthus, L.
altissimus, L.
decapetalus, L. A. and N. B.
divaricatus, L. B.
truncatus, Schw.
trachelifolius, W. B—e. M.A.Curtis.
§ tuberosus, L. *Artichoke.*
Helenium, L.
autumnale, L. B—e.
Hieracium, L.
Gronovii, L. A.
kalmii, L. *H. virgatum, and H. fasciculatum, Ph.*
marianum, W.
paniculatum, W.
venosum, L. *Hawkweed.*
Inula, L.
helenium, L. *Elecampane.*
falcata, Ph. N. B. and Nantucket. *Chrysopsis falcata, Beck.*
Iva, L.
frutescens, L. *High Water Shrub.* B—e.
Krigia, L.
amplexicaulis, Nutt. A. *Hyoseris amplexicaulis, Mx. Cynthia amplexicaule, Beck.*
Virginica, W. *Dwarf Dandelion. C. Virginica, Beck.*
Lactuca, L.
elongata, Muhl. *Wild Lettuce.*
integrifolia, Big. B. and A.
sanguinea, Big. B.
villosa, Jacq. Massachusetts. Beck.
Leontodon, L.
taraxicum, L. *Dandelion.*
Liatris, L.
scariosa, W. *Gay Feather.*
spicata, W. B—e. M. A. Curtis.
Mikania, W.
scandens, W. *Climbing Thorough Wort.* A &B.

Onopordon, L.
§ acanthium, L. *Cotton Thistle.*
Prenanthes, L.
alba, L. *Harpalyce alba, Don. White Lettuce.*
altissima, L. *H. altissima, Don.*
cordata, Ph. *H. cordata, Don.*
virgata, Mx. *H. virgata, Don.*
Rudbeckia, L.
laciniata, L. *Cone Flower.*
Senecio, L.
aureus, L. *Rag Wort.*
balsamitæ, W. *Balsam Groundsel.*
hieracifolius, L. *Fire Weed.*
obovatus, W.
vulgaris, L. *Groundsel.*
Solidago, L. *Golden Rod.*
altissima, W.
arguta, W.
aspera ? Ait.
bicolor, L.
cæsia, W.
Canadensis, L. B—e.
ciliaris ? W.
gigantea, Ait.
lanceolata, Ait.
lævigata, Ait. B.
latifolia, Muhl.
livida, W.
nemoralis Ait.
odora, Ait. *Sweet scented golden rod.*
rigida, Ait. South Hadley Canal.
serotina, W.
speciosa, Nutt. A.
squarrosa, Nutt. Mt. Holyoke.
stricta, W.
tenuifolia, Ph. Nantucket. T. A. Greene.
ulmifolia, W.
Sonchus, L.
acuminatus, W.
oleraceus, L. *Sow Thistle.*
spinulosus, Big. B.
Tussilago, L.
farfara, W. *Colt's Foot.*
palmata, Ait. Sunderland.
Tanacetum, L.
§ vulgare, L. *Tansey.*
Vernonia, L.
noveboracensis, W. *Flat Top.*
Xanthium, L.
spinosum, L. Plainfield. Dr. Porter.
strumarium, L. *Clott Burr.*

STELLATÆ.

Galium, L
aparine. L.
asprellum, Mx. *Rough Bed Straw.*
boreale, Ph. *Septentrionale, R. and S.*
circæzans, Mx. *Liquorice.*
lanceolatum, Torrey. *Torreyi, Big.*

obtusum, Big. B.
pilosum, Ait.
tinctorium, L. *Dyers Cleavers.*
trifidum, L. *Bed Straw. Small Cleavers.*
triflorum, Mx.
verum, L. B.

CINCHONEÆ.

Cephalanthus, L.
occidentalis, L. *Button Bush.*
Mitchella, L.
repens, L. *Checker Berry. Eye Bright.*

CAPRIFOLIACEÆ.

Caprifolium, Goldie.
pubescens, Goldie. *Lonicera hirsuta, Eaton. Rough Woodbine.*
Cornus, L.
alba, l'Her. B.
alternifolia, L. B.
Canadensis, L. *Dog Wood.*
circinata, l'Her.
florida, L. *Dog Wood.*
paniculata, l'Her.
sanguinea, l'Herit. B—e.
sericea, l'Her.
Diervilla, Tourn.
humilis, Pers. *Lonicera diervilla, L. Bush Honeysuckle.*
Linnæa, Gron.
borealis, Gron. *Twin Flower.*
Lonicera, L.
parviflora, Lmk.
Sambucus L.
Canadensis, L. *Elder.*
pubens, Mx. *Red Berried Elder.*
Triosteum, L.
perfoliatum, L. *Fever Root.* Deerfield and Cambridge.
Viburnum, L.
acerifolium, L. *Maple Guelder Rose.*
dentatum, L. *Arrow Wood.*
lantanoides, Mx. *Hobble Bush. Tangle Legs.*
lentago L. *Sheep Berry.*
nudum, L.
oxycoccus, Ph. *High Cranberry.*
pyrifolium, Lam. Williamstown.
Xylosteum, Tourn.
ciliatum, Ph. *Lonicera ciliata, Muhl. Fly Honeysuckle.*
villosum, Mx. Deerfield and Williamstown.

ASCLEPIADEÆ.

Asclepias L. *Milk Weed.*
incarnata, L.
obtusifolia, Mx.
phytolaccoides, Ph. *exaltata et acuminata, Muhl.*
quadrifolia, Jacq.
pulchra, W. B. Malden, M. A. Curtis.
purpurascens, L. B.
syriaca, L. *Common Milk Weed.*
tuberosa, L. *Pleurisy Root. Butterfly Weed.*
variegata, L.
verticillata, L.
viridiflora, Ph. B. and Leicester.

APOCYNEÆ.

Apocynum, L.
androsæmifolium, L. *Dog Bane.*
cannabinum, Mx. *pubescens, Brown.*
hypercifolium, Ait. *John's Dog Bane.*

GENTIANEÆ

Gentiana, L.
crinita, W.
quinqueflora, W. Charlemont and Hoosic Mt.
pneumonanthe, L. B.
saponaria, L. *Soap Gentian.*

Houstonia, L.
cœrulea, L. *Venus' Pride.*
longifolia, Willd. B.

Menyanthes, L.
trifoliata, L. *Buck Bean.* B. and A.

Sabbatia, Adanson.
chloroides, Ph. B.
stellaris, Ph. N. B.

Villarsia, Vent.
lacunosa, Ph. B. *Menyanthes trachysperma, Mx. Spur Stem. Floating Heart.*

CONVOLVULACEÆ.

Convolvolus, L.
arvensis, L. B.
sepium, L. *Field Bind Weed.*
stans, Mx. *spithamæus, L. Dwarf Morning Glory.*

Cuscuta L.
Americana, L. *Dodder.*

OLEACEÆ.

Fraxinus, L.
Americana, W. *White Ash.*
juglandifolia, Lam. *Swamp Ash. A.*
sambucifolia, W. *Black Ash. A.*

Ligustrum, L.
vulgare, L. *Privet or Prim.* A. and B.

PRIMULACEÆ.

Anagallis, L.
arvensis, L. *Scarlet Pimpernel.*

Hottonia, L.
inflata, L. B. and N. B.

Glaux, L.
maratima, L. Barnstable and Yarmouth, Dr. K. Underwood. *Black salt Wort.*

Lysimachia, L.
capitata, Ph. A. and B.
ciliata, L.
hybrida, Mx. B. and N. B.
quadrifolia, L.
racemosa, Ph. *stricta, Ait. Loose Strife.*

Samolus, L.
valerandi, L. *Brook Weed. B.*

Trientalis, L.
Americana, Ph. *Chick Wintergreen.*

LENTIBULARIÆ.

Utricularia, L.
- cornuta, Mx. *Leafless Bladder Wort.* A. and B.
- gibba, Gron. B—e.
- inflata, Walt. B.
- pupurea, Walt. B.
- resupinata, Green. MS. Tewksbury.
- striata, LeConte. A.
- vulgaris, L. *Bladder Wort.*

OROBANCHEÆ.

Epiphagus, Nutt.
- Americanus, Nutt. *Orobanche Virginiana, L. Cancer Root.*

Orobanche, L.
- Americana, L. Mount Holyoke.
- uniflora, L. *Cancer Root.*

SCROPHULARINEÆ.

Antirrhinum, L.
- Canadense, W. *Flax Snap Dragon.*
- elatine, L. Hadley. Dr. George White.
- § linaria, L. *Snap Dragon.*

Chelone, L.
- glabra, L. *Snake Head.*

Gerardia, L.
- flava, L.
- glauca, Eddy. *Fox Glove.*
- maritima, Raf. B.
- pedicularia, L.
- purpurea, L.
- tenuifolia, L. B.

Gratiola, L.
- aurea, Muhl. *Hedge Hyssop.*
- Virginica, L. *neglecta, Torrey. A.*

Leptandra, Nutt.
- Virginica, Nutt. *Callistachya Virginica. Raf. Culver's Physic.*

Limosella, L.
- subulata, Ives. *Mudwort.* Nantucket.

Lindernia, L.
- attenuata, Muhl. *False Hedge Hyssop.*
- dilatata, Muhl. B. and A.

Mimulus, L.
- alatus, L. A.
- ringens, L. *Monkey Flower.*

Penstemon, L.
- pubescens, L. B—e.

Scrophularia, L.
- Marilandica, L. *Fig Wort.*

Veronica, L.
- agrestris, L.
- anagallis, L. *Brook Pimernel.*
- arvensis, L. *Wall Speedwell.*
- beccabunga, L.
- officinalis, L. *Speedwell*
- peregrina, L. N. B.
- scutellata, L.
- serpyllifolia, L.

RHINANTHACEÆ.

Bartsia, L.
coccinea, L. *Euchroma coccinea, Nutt.* *Painted Cup.*
Melampyrum, L.
Americanum, Mx. *Cow Wheat.*
Pedicularis, L.
Canadensis, L. *Louse Wort.*
pallida, Ph. A.
Rhinanthus, L.
crista galli, L. *Yellow Rattle.* Plymouth. Bigelow.

SOLANEÆ.

Datura, L.
stramonium, L. *Thorn Apple.*
Hyoscyamus, L.
§ niger, L. *Hen Bane.*
Nicandra, Adans.
§ physaloides, Pers. N. B.
Physalis, L.
obscura, Mx. *Hen Bane.* A.
Pennsylvanica ? L. A.
Solanum, L.
§ dulcamara, L. *Bitter Sweet.*
nigrum, L. *Deadly Nightshade.*
Verbascum, L.
blattaria, L. *Sleek Mullein.* B. and A.
thapsus, L. *Mullein.*

VERBENACEÆ.

Phryma, L.
leptostachia, L. *Lop Seed.*
Verbena, L.
angustifolia, Mx. A.
hastata, L. *Vervain.*
urticifolia, L. *Nettle Leaf Vervain.*

LABIATÆ.

Ballota, L.
§ nigra, L. *Black Horehound.* B.
Clinipodium, L.
vulgare, L. *Field Thyme.* A.
Collinsonia. L.
Canadensis, L. *Horse Balm.*
Galeopsis, L.
§ ladanum, L. B. *Hemp Nettle.*
§ tetrahit, L. *Flowering Nettle.*
Glechoma, L.
hederacea, L. *Gill-grow-by-the-ground*
Hedeoma, Pers.
pulegioides, Pers. *Pennyroyal.*
Isanthus, Mx.
coeruleus, Mx. *False Pennyroyal.*
Lophanthus, Benth.
nepetoides, Benth. *Hyssopus nepetoides, W* *Giant Hyssop.*
Lamium, L.
§ amplexicaule, L. *Hen Bit.* *Dead Nettle.*
Leonorus, L.
cardiaca, L, *Motherwort.*

Lycopus, L.
Europæus, L. *Water Horehound.*
Virginicus, L. *Bugle Weed.*
Marrubium, L.
§ vulgare, L. *Horehound.*
Mentha, L.
borealis, Mx. *Horsemint.*
§ piperita, L. *Peppermint.*
viridis, Walter. *Spearmint.*
Monarda, L.
clinopodia, L. B—e.
didyma, L. B—e.
hirsuta, Ph. Soapstone Quarry, Windsor. Dr. Porter.
oblongata, Ait. B- e. and B. *allophyllus, Mx.*
Nepeta, L.
cataria, L. *Catmint:*
Prunella, L.
Pennsylvanica, W. *Heal All.*
Pycnanthemum, Mx.
aristatum, Mx.
incanum, Mx. *Mountain Mint.*
lanceolatum ? Ph.
linifolium, Ph. *Virginian Thyme.*
verticillatum, Pers. B—e.
Scutellaria, L.
galericulata, L. *Scull Cap.*
laterifolia, L. *Mad-dog Scull Cap.*
Stachys, L.
aspera, Mx. *Hedge Nettle.*
sylvatica, L. A.
hyssopifolia, Mx. N. B.
Teucrium, L.
Canadense, L. *Wild Germander.*
Trichostema, L.
dichotoma, L. *Blue Curls.*
Thymus, L.
§ vulgaris, L. *Thyme.* Longmeadow.

BORAGINEÆ.

Cynoglossum, L.
§ officinale, L. *Hound Tongue.*
Virginicum, L. B—e.
Echium, L.
vulgare, L. *Viper's Bugloss. B.*
Lithospermum, L.
arvense, L. B. *Common Gromwell.*
officinale, L. B—e.
Lycopsis, L.
§ arvensis, L. A. and B. *Wild Bugloss.*
Myosotis, L.
§ arvensis, Sibth. *Forget-me-not.*
palustris, Rostk. B.
Virginiana, L. *Echinospermum Virginicum, Lehm. Mouse Ear.*
Onosmodium, Mx.
hispidum, Mx. Monson and Nantucket. *False Gromwell.*

HYDROPHYLLEÆ.

Hydrophyllum, L.
Canadense, L. Windsor. Dr. Porter.
Virginicum, L. A. *Water Leaf.*

TRIBE II.—GYMNOSPERMÆ.

CONIFERÆ.

- Cupressus, L.
  - thuyoides, L. *White Cedar.* A. B. and especially N. B.
- Juniperus, L.
  - communis, L. *Juniper.* Mount Tom and B.
  - Virginiana, L. *Red Cedar.*
- Pinus, L.
  - alba, Ait. *Spruce.*
  - balsamea, W. *Fir Tree. Balsam Tree.*
  - Canadensis, L. *Hemlock Tree.*
  - fraseri, Ph. Saddle Mountain. Dewey.
  - nigra, Ait. *Black Spruce.*
  - pendula, Ait. *Hackmatack. Tamarack.*
  - resinosa, Ait. *Norway Pine.* A and Worcester Co.
  - rigida, L. *Pitch Pine.*
  - strobus, L. *White Pine.*
- Taxus, L.
  - Canadensis, W. *Dwarf Yew.* A. Very common.

SUB-CLASS II.—ENDOGYNÆ OR MONOCOTYLEDONOUS PLANTS.

TRIBE I.—PETALOIDEÆ.

ALISMACEÆ.

- Alisma. L.
  - plantago, L. *Water Plantain.*
- Sagittaria, L.
  - acutifolia, Ph. *Arrow Head.*
  - heterophylla, Ph.
  - obtusa, W. N. B. Var. of S. sagittifolia.
  - sagittifolia, L. *Arrow Head. α latifolia. β gracilis.*

HYDROCHARIDEÆ.

- Udora, Nutt.
  - Canadensis, Nutt. *Serpicula verticillata, Muhl.*
- Valisneria, L.
  - spiralis, Mx. *Tape Grass.* Cambridge and Connecticut river.

XYRIDEÆ.

- Xyris, L.
  - Caroliniana, Walt. *Yellow-eyed Grass.*

HYPOXIDEÆ.

- Hypoxis, L.
  - erecta, L. *Star Grass.*

IRIDEÆ.

- Iris, L.
  - versicolor, L. *Wild Iris. Blue Flag.*
  - Virginica, Torrey. *gracilis, Big. Boston Iris.*
- Sisyrinchium, L.
  - anceps, L. *Blue-eyed Grass.*

ORCHIDEÆ.

- Aplectrum, Nutt.
  - hyemale, Nutt. *Cymbidium hyemale, W. Putty Root. Adam and Eve.* Conway.

- **Arethusa, L.**
  - bulbosa, L. B. and Belchertown.
- **Calopogon, Brown.**
  - pulchellus, Br. *Cymbidium puchellum, W. Grass Pink.*
- **Corallorhiza, Brown.**
  - odontorrhiza, Nutt. *Cymbidium odontorizon, W. Coral Teeth. Dragon Claw.*
- **Cypripedium, L.**
  - humile, Sw. *acaule, Ait. Ladies' Slipper.*
  - pubescens, Sw. *Yellow do.*
  - spectabile, Sw. *Canadense, Mx.* Deerfield.
- **Goodyera, Brown.**
  - pubescens, Br. *Neottia pubescens, W. Rattle Snake Leaf.*
  - repens, Br. B.
- **Habenaria, W.**
  - blephariglottis, Hooker. A. and B. *Orchis blephariglottis, W.*
  - bracteata, R. Brown. *Satyrium bracteatum, Ph. O. bracteata, W.*
  - cristata, R. Brown. *O. cristata, Mx.* Fair Haven, T. A. Greene.
  - ciliaris, R. Brown. A. and B.
  - grandiflora, Tor. B. and A. *O. grandiflora, Big.*
  - herbiola, R. Brown. A. and N. B.
  - incisa? Spreng.
  - fimbriata, R. Brown.
  - macrophylla, Goldie. Mt. Holyoke.
  - psycodes, Spreng. B—e and A.
  - tridentata, Hook.
- **Listera, R. Brown.**
  - cordata, Brown. Plainfield.
- **Malaxis, Sw.**
  - liliifolia, Sw. *Liparis liliifolia, Rich. Tway blade.*
  - lœselii, Sw.
- **Mycrostylis, Nutt.**
  - ophioglossoides, Nutt. *Adder Mouth.*
- **Neottia, Sw.**
  - tortilis, Sw. *β gracilis, Torrey. Spiranthes tortilis, Rich. Ladies' Tresses.*
  - cernua, W. *S. cernua, Rich.* B—e A. and N.B. *Nodding Ladies' Tresses.*
- **Orchis, L.**
  - spectabilis, L. *Orchis.*
- **Platanthera, Rich.**
  - dilatata, Lindley. *Orchis dilatata, Ph.*
  - orbiculata, Lindley. *O. orbiculata, Ph.*
- **Pogonia Brown.**
  - ophioglossoides, Brown. *Snake Mouth Arethusa.*
  - verticillata, Nutt. A.
- **Triphora, Nutt.**
  - pendula, Nutt. *Arethusa pendula, W.* Deerfield.

JUNCEÆ.

- **Juncus, L.**
  - acuminatus, Mx. A.
  - bufonius, L.
  - bulbosus, L.
  - effusus, L. *Bulrush.*
  - militaris, Big. Tewksbury.
  - marginatus, Rostk. N. B.
  - nodosus, L.
  - polycephalus, Mx.
  - setaceus, Rostk.
  - tenuis, W.

Luzula, De Cand.
campestris, De Cand.
melanocarpa, Desv.
pilosa, W. A.

MELANTHACEÆ.

Helonias, L.
dioica, Ph. B—e. *Blazing Star.*
Veratrum, L.
viride, Ait. *Indian Poke. White Hellebore.*

PONTEDEREÆ.

Pontederia, L.
angustifolia, Ph. Leverett. *P. cordata, β angustifolia, Torrey.*
cordata, L. *Pickerel Weed.*
Schollera, Schreb.
graminea, Vahl. *Leptanthus gramineus, Mx. Heteranthea [graminea, Ph.*

ASPHODELEÆ.

Aletris, L. *A. alba, Mx.*
farinosa, L. *False Aloe.* A.
Allium, L.
Canadense, L. *Meadow Garlic.*
tricoccum, Ait.
Asparagus, L.
§ officinalis, L.

SMILACEÆ.

Convallaria, L.
bifolia, L. *Styrandra bifolia, Raf. Smilacina Canadensis, Ph.*
canaliculata, W. B. B—e.
multiflora, L. *Polygonatum multiflorum, Des. Solomon Seal.*
pubescens, W. A. *Polygonatum pubescens, Ph.*
racemosa, L. *Smilacina racemosa, Des. Clustered Solomon Seal.*
stellata, L. *S. stellata, Des.*
trifolia, L. Pelham, Cumington, and Tewksbury. Mr. Curtis. [*S. trifolia, Des.*
umbellulata, Mx. *Dracæna borealis, L. Lily of the Valley.* A.
Gyromia, Nutt.
Virginica, Nutt. *Medeola Virginica, L. Indian Cucumber.*
Smilux, L.
herbacea, L: B—e.
peduncularis, Muhl. *Jacobs' Ladder.*
rotundifolia, L. *Green Briar.*
Streptopus, Mx.
distortus, Mx. A. & B—e. *Uvularia amplexifolia, L.*
roseus, Mx. *U. roseus, Muhl. Rose Bell Wort.* A. & B—e.
Trillium, L.
cernuum, L. *Nodding Wake Robin.*
erectum, L. *False Wake Robin.*
grandiflorum, Salisb. Pelham. Dr. G. White.
pictum, Ph. *T. undulatum. W. Smiling Wake Robin.*
Uvularia, L.
perfoliata, Mx. *U. grandiflora, Smith. Bell Wort.*
sessifolia, L.

DIOSCOREÆ.

Dioscorea, L.
villosa, L. B.

LILIACEÆ.

Erythronium, L.
dens-canis, Mx. *E. Americanum, Smith. Dog Tooth Violet.*
Lilium, L.
Canadense, L. *Nodding Lily.*
Philadelphicum, L. *Red Lily.*
superbum, L. B.

RESTIACEÆ.

Eriocaulon, L.
gnaphalioides, Mx. B—e.
pellucidum, Mx. *Pipe Wort.*

TYPHACEÆ.

Sparganium, L.
Americanum, Nutt. N. B.
angustifolium, Mx ? B.
ramosum, Smith. *Burr Reed.*
Typha, L.
angustifolia, L. B.
latifolia, L. *Cat Tail.*

AROIDEÆ.

Acorus, L.
calamus, L. *Sweet Flag.*
Arum, L.
dracontium, L. *Green Dragon.* Deerfield.
triphyllum, L. *Indian Turnip.*
Calla, L.
palustris, L. *Water Arum.*
Lecontia, Cooper. ' A true Celadium.' Torrey.
Virginica, Coop. *Arum Virginicum, L. Rensselæria Virginica,* [*Beck.* Belchertown.
Orontium, L.
aquaticum, L. *Golden Club.* Southwick. Dr. Porter.
Pothos, Mx.
fœtida, Mx. *Symplocarpus fœtidus, Nutt. Ictodes fœtidus, Big.* [*Skunk's Cabbage.*

FLUVIALES.

Najas, L.
Canadensis, Mx. *Caulinia flexilis, W.* A.
Potamogeton, L.
compressum, W. A. and N. B.
fluitans, L.
gramineum, Mx. A. and B. *pauciflorum, Ph.*
heterophyllum, Schreb. A.
lucens, Mx. B.
natans, L.
pectinatum, L. B—e. and N. B.
perfoliatum, L.
setaceum, Ph. *diversifolium, Barton.* A. and B.
Ruppia, L.
maritima, L. *Sea Teazel Grass.* B.
Zostera, L.
marina, L. *Grass Wrack.*

JUNCAGINEÆ.

Scheuchzeria, L.
palustris, L. Belchertown.
Triglochin, L.
maritimum, L. *Arrow Grass.* B.

PISTIACEÆ.

Lemna, L.
minor, L. *Duck-meat.*
polyrrhiza, L. *Waterflax Seed.* A.
trisulca, L. A.

TRIBE II.—GLUMACEÆ.

GRAMINEÆ.

Agrostis, L.
canina, W. B.
clandestina, Spreng. B.
lateriflora, Mx. A & N. B.

- Agrostis, L.
  - longifolia. Torrey. A.
  - polymorpha, Trinnius. *alba, L. A. White Top Grass.*
  - sobolifera, Muhl. A.
  - sylvatica, Torrey. B—e.
  - tenuiflora, Willd. A.
  - Virginica, L.
  - vulgaris, Smith.
- Aira, L.
  - flexuosa, L. *Hair Grass.*
- Alopecurus, L.
  - geniculatus, L. *Floating Fox Tail.*
  - pratensis, L. *Meadow Grass.*
- Andropogon, L.
  - furcatum, Muhl. *Forked Spike.*
  - macrourum, Mx. N. B.
  - nutans. L. *Beard Grass.*
  - purpurascens, Muhl. N. B.
  - Virginicum ? L. N. B.
- Anthoxanthum, L.
  - odoratum, L. *Sweet Vernal Grass.*
- Aristida, L.
  - dichotoma, Mx. *Beard Grass.*
  - gracilis, Ell. N. B.
  - purpurascens, Poir. *A. racemosa, Muhl.* N. B. & A.
- Arrhenatherum, P. de B.
  - avenaceum, P. de B. *Avena elatior. L.*
  - Pennsylvanicum, Torrey. B—e.
- Arundo, L.
  - Canadensis, Mx. *Calamagrostis Mexicana, Nutt.* B. & A.
  - coarctata, Torrey. *Canadensis, Nutt.* B. & A.
- Briza, L.
  - media, L. B.
- Bromus, L.
  - ciliatus, L. B—e.
  - purgans, L. B.
  - pubescens, Muhl. *Broom Grass.*
  - { secalinus, L. *Chess. Cheat.*
  - mollis, L.
- Cenchrus, L.
  - echinatus, L. Near Boston. Mr. M. A. Curtis.
- Cinna, L.
  - arundinacea, W. *Indian Reed.*
- Danthonia, De Cand.
  - spicata, P. de B. *Avena spicata, L. Wild Oats.*
- Dactylis, L.
  - glomerata, L. *Orchard Grass.*
- Digitaria, Haller.
  - filiformis, Ell. A. & N. B.
  - sanguinalis, Scop. *Finger grass. A. & B—e.*
- Elusine, Gærtner.
  - indica, Lamb. *Cynosurus indica, L. Wire Grass. A.*
- Elymus, L.
  - Canadensis, L. β. glaucifolius, Torrey.
  - hystrix, L.
  - villosus, Muhl. *Wild Rye. Lime Grass.*
  - Virginicus, L.
- Festuca, L.
  - duriuscula, L. N. B.
  - elatior, L. *Fescue Grass.*
  - pratensis, Huds. B—e,

- **Festuca, L**
  - nutans, W.
  - tenella, W. A. & B—e.
- **Glyceria, R. Brown.**
  - fluitans, R. Brown. *Festuca fluitans, L. Water Fescue.*
  - acutiflora, Torrey.
- **Hierochloa, Gmelin.**
  - borealis, R & S. *Holcus odoratus. L. Seneca Grass. B.*
- **Holcus, L.**
  - lanatus, L. *Velvet grass, B.*
- **Hordeum, L.**
  - jubatum, L. B.
- **Kœleria, Pers.**
  - Pennsylvanica, De Cand. *Aira mollis, Muhl. A.*
  - truncata, Torrey. *A. truncata, Muhl.*
- **Leersia, Swartz.**
  - oryzoides, Sw.
  - Virginica, W. *Cut Grass.*
- **Lolium, L.**
  - perenne, L. *Darnel Grass.*
- **Muhlenbergia, Schreb.**
  - erecta, S. *Drop Seed-grass.*
- **Oryzopsis, Mx..**
  - asperifolia, Mx. *Mountain Rice.*
- **Panicum, L.**
  - agrostoides, Muhl. A. & N. B.
  - anceps, Mx. Cambridge. Mr. M. A. Curtis.
  - capillare, L.
  - clandestinum, L. A.
  - crus-galli, L. *Barn-Grass.*
  - dichotomum, L.
  - depauperatum, Muhl. A. and B—e.
  - discolor, Muhl. B.
  - geniculatum, Muhl. *proliferum, Lam. A.*
  - hispidum, Muhl. A. and N. B.
  - involutum, Torrey. A.
  - latifolium, L.
  - macrocarpon, Torrey. A.
  - nervosum, Muhl. A. and B.
  - nitidum, Lmk.
  - virgatum, L. A. and B.
- **Paspalum, L.**
  - ciliatifolium, Mx. N. B.
  - setaceum, Mx. *Paspalon Grass.* A. Woburn. Mr. Curtis.
- **Phalaris, L.**
  - Americana, Ell. *Calamagrostis colorata, Nutt. Ribbon Grass.*
- **Phleum, L.**
  - pratense, L. *Timothy Grass.*
- **Piptatherum, Beauv.**
  - nigrum, Torrey. *Oryzopsis Melanocarpa, Muhl. Milium* [*racemosum, Smith. Clustered Millet-Grass.*
- **Poa, L.**
  - annua, L.
  - aquatica, β Americana, Torrey.
  - Canadensis, Torrey.
  - capillaris, L. A. and B.
  - compressa, L.
  - dentata, Torrey. A. N. B. and B—e.
  - elongata, Torrey. *Torreyi, Spreng.*
  - eragrostis, L. A. and B.
  - hirsuta, Mx. A. and B.
  - maritima, Huds. B.

- Poa, L.
  - nemoralis, L. A. and B—e.
  - nervata, W.
  - obtusa, Muhl. B.
  - palustris, Muhl. A.
  - pectinacea, Mx. A.
  - pratensis, L.
  - reptans, Mx. A.
  - trivialis, L. A. N. B. and B—e.
- Polypogon, Des.
  - glomeratus, W. *Agrostis racemosa, Mx. racemosus, Nutt.* A.
- Phragmites, Trinnius.
  - communis, Trin. *Arundo phragmites, W.*
- Psamma, P. de Beauv.
  - arenaria, P. de Beauv. *Arundo arenaria, L. B.*
- Setaria, P. de Beauv.
  - viridis, P. de B. *Panicum viride, L.*
  - glauca, P. de Beauv. *Panicum glaucum, L. Fox-tail Grass.*
  - italica, P. de Beauv. B—e. *P. italicum, L.*
  - verticillata, P. de Beauv. Boston. *P. verticillatum, L.*
- Spartina, Schreb.
  - cynosuroides, W. B. *Limnetis cynosuroides and polystachia, Ph. Rough Grass.*
  - glabra, Muhl. B.
  - juncea, W. B. *L. juncea, Ph.*
- Stipa, L.
  - avenacea, L. B.
  - Canadensis, Lmk. A. and B. *Milium pungens, Torrey Oryzopsis parviflora, Nutt.*
- Trichochloa, De Cand.
  - capillaris, De Cand. *Agrostis sericea, Muhl.* Sugar Loaf, Deerfield. Dr. Cooley.
- Trichodium, Mx.
  - laxiflorum, Mx. *Tickle Grass.*
  - scabrum, Muhl. A. and B—e.
- Tricuspis, Pe de Beauv.
  - sesleroides, Torrey. *Poa quinquefida, Ph.* A. and B—e.
- Trisetum, Pers.
  - palustre, Torrey. *Aira pallens, Muhl.*
  - purpurascens, Torrey. B—e.
- Triticum, L.
  - repens, L. *Wheat Grass. Quake Grass.* B.
- Uniola, L.
  - spicata, L. *Spike Grass.* B.
- Uralepsis, Nutt.
  - aristulata, Nutt. N. B.
- Zizania, L.
  - clavulosa, Mx. *Water Oats. Wild Rice.* B. and Northampton.

CYPERACEÆ.

- Carex, L. *Sedge Grass.*
  - acuta, L. A. and B—e.
  - alba, Hænke, B—e.
  - alpestris, All.
  - ampullacea, W. Deerfield.
  - anceps, Muhl. A. B—e and B.
  - aquatilis, Wahl. B—e.
  - aurea, Nutt. B—e.
  - blanda, Dewey. A. and B—e.
  - bromoides, Schk. A. and B—e.
  - bullata, Schk. A. and B—e.
  - Buxbaumii, Wahl. A.
  - cæspitosa, L. A. and B - e. and B.

Carex, L.
cephalophora, Muhl. A. B. and B—e.
collecta, Dewey. Worthington.
conoidea, Schk. A. and B—e.
crinata, Lamk. A. B—e. and B.
cristata, Schw. A. and B—e.
curta, Good. B. A. and B—e.
Davisii, Dewey. A. and B—e.
Deweyana, Schw. A. and B—e.
disperma, Dewey. A. and B—e.
festucacea, Schk. A. and B—e.
filiformis, L. A. and B—e.
flava, L.
flexuosa, Muhl. A. and B.
folliculata, L. A. B—e. and B.
formosa, Dewey. A. and B—e.
gracillima, Dewey. A. and B—e.
granularis, Muhl. A. and B—e.
Halseyana, Dewey. Westfield.
hirsuta, W. A. and B—e.
Hitchcockiana, Dewey. Williamstown.
hystericina, W. A. and B.
lacustris, W. A. B—e. and B.
lagopodioides, Schk. A. and B—e.
laxiflora, Lam. A. and B—e.
limosa, L. Ashfield.
longirostris, Torrey. A. and B—e.
lupulina, Muhl. A. B—e. and B.
marginata, Muhl. A. B—e. and B.
miliacea, Muhl. A. and B—e.
Muhlenbergii, Schk. B—e.
multiflora, Muhl. B—e.
muricata. B—e.
Novæ-Angliæ, Schw. A. and B—e.
oligocarpa, Schk. A. and B—e.
pallescens, L. A. and B—e.
paniculata, L. A. and B.
pauciflora, Light. Ashfield.
pedunculata, Muhl. A. and B—e.
pellita, Muhl. A.
plantaginea, Lam. A. B—e. and B.
polytricoides, Muhl. A. and B—e.
pseudo-cyperus, L. A. B—e. and B.
pubescens, Muhl. A. and B—e.
retroflexa, Muhl. A. and B—e.
retrorsa, Schw. B—e. and Plainfield.
rosea, Schk. A. and B—e.
scabrata, Schw. A. and B—e.
scirpoides, Schk. A. and B—e.
scoparia, Schk. A. B—e. and B.
Schweintzii, Dewey. B—e.
setacea, Dewey. B—e.
siccata, Dewey. Westfield.
sparganoides, Muhl. A. B—e. and B.
squarrosa, L. Hadley.
stellulata, Good. A. B—e. and B.
sterilis, W. A. and B—e.
stipata, Muhl. A. B—e. and B.
straminea, W. A. B—e. and N. B.
stricta, Good. A. and B—e.
sylvatica, Huds. A. and B—e.
tenera, Dewey. A. and B—e.
tentaculata, Muhl. A. B—e. and N. B.
teretiuscula, Good. A. and B—e.
tetanica, Schk. A. and B—e.
Torreyana, Dewey. A. and B—e.
triocarpa, Muhl. A. and B—e.
trisperma, Dewey. A. and B—e.

Carex, L.
umbellata, Schk. A. and B—e.
varia, Muhl. A. and B—e.
vesicaria, L. A.
vestita, W. A.
virescens, Muhl. A. B—e. and N. B.
xanthophysa, Wahl. A. B—e. and N. B.

Cyperus, L.
Nuttallii, Torrey. A.
dentatus, Torrey. A. and B.
diandrus, Torrey. A. and B.
flavescens, L. N. B. and B—e.
mariscoides, Ell. *Scirpus cyperiformis, Muhl.* A. and B.
strigosus, L. A. and B—e.
uncinatus, Ph. *inflexus, Muhl.* A. and B.

Dulichium, Richard.
spathaceum, Pers. *Galingale.*

Eriophorum, L.
alpinum, L. (*See Torrey's Flora.*)
augustifolium, Roth. A. and B.
cespitosum, Ph. A. and B—e.
polystachium, L. A. B. and B—e.
Virginicum, L. *Cotton Grass.* A. B. and B—e.

Fuirena, L.
squarrosa, of authors, not of Mx. Tewksbury. Mr. A Curtis.

Rhyncospora, L.
alba, Vahl. A. B. and B—e.
glomerata, Vahl. A.
macrostachya, Torrey. MS. Belchertown and Leverett.

Scirpus, L. *Rush.*
acicularis, L. *S. trichodes. Muhl.* A. B. & B—e.
acutus Muhl. B. and B—e.
atrovirens, Muhl. A. and B—e.
autumnalis, Muhl. A. and B.
brunneus, Muhl. A.
capillaris, L. A. and B.
capitatus, L. A. B. and B—e.
debilis, Muhl. A. and B.
eriophorum, Mx. A. and B. *Tricophorum cyperinum, Pers.*
intermedius, Muhl. A.
lacustris, L. A.
lineatus, Mx. Plainfield. *Tri. lineatum, Pers.*
maritimus, L. B.
palustris, L. A. and B.
planifolius, Muhl. A. B. and B—e.
subsquarrosus, Muhl. A.
subterminalis, Torrey. Leverett.
tenuis, W. A. B. and B—e.
triqueter, Mx. A. and B—e. *S. Americanus, Pers.*
tuberculosus, Mx. A.

Scleria, L.
triglomerata, Mx. *Whip Grass.*

Schœnus, L.
mariscoides, Muhl. *Bog Rush.* Belchertown and Leverett.

CLASS II.—CELLULARES,

OR

FLOWERLESS PLANTS.

TRIBE I.—FILICOID PLANTS.

EQUISETACEÆ.

Equisetum, L.
arvense, L. *Horse Tail.* A. B. and B—e.
hyemale, L. *Rough Horse Tail. Scouring Rush.* A. B. and B—e.
sylvaticum, L. A. B. and B—e.
palustre, L. A.
scirpoides, Mx. *E. variegatum, Smith.* A. B. and B—e.
uliginosum, W. *E. limosum, L. Pipes.* A. B. and B—e.

FILICES.

Adianthum, L.
pedatum, L. *Maiden Hair. Mow Hair.*
Aspidium, Swartz. *Brake. Fern.*
acrostichoides, W. A. B. and B—e.
angustum, W. B—e.
asplenoides, W. A. and B.
bulbiferum, W. B—e.
cristatum, W. A.
dilatatum, W. *intermedium, L.* A. N. B. and B—e.
tenue, Ph. A.
Goldianum, Hooker. *Felix-Mas.* Ph. A and B—e.
intermedium, Muhl. Dr. Porter.
lancastriense, Muhl. B.
marginale, W. *Nephrodium marginale, Mx.* N. B. and B—e.
noveboracense, W. A. B. and B—e.
spinulosum, W. B—e.
thelypteris, Willd. B. and Plainfield.
Asplenium, L. *Brake. Fern.*
angustifolium, Mx. *Spleen Wort.* B—e. B. and A.
ebenum, W. B—e. B. and A.
melanocaulon, W. B—e. B. and A.
rhizophyllum, W. *Walking Leaf.* B—e. B. and A.
ruta-muraria, L. B—e. B. and A.
thelypteroides, Mx. *acrostichoides, Sw.* B—e. B. and A.
Botrychium, Swartz.
fumaroides, W. *Grape Fern.* A. B. and B—e.
simplex, Hitchcock. A.
Virginicum, Swartz. A. B. and B—e.
Dicksonia, l'Herit.
pilosiuscula, W. *Aspidium punctilobum, W.*
Hypopeltis, Torrey.
obtusa, Torrey. *Aspidium obtusum,* W. *Woodsia periniana,* A. *Hook. and Grev.*
Lygodium, Sw.
palmatum, Swartz. *Climbing Fern.* Amherst and Becket.
Onoclea, L.
sensibilis, L. *Sensitive Fern.* A. B. and B—e.
Ophioglossum, L.
vulgatum, L. *Adder Tongue Fern.* A.
Osmunda, L.
cinnamonea, L. B—e. and A.

Osmunda, L.
interrupta, Mx. B. B—e. and A.
spectabilis, *O. regalis, Mx.* W. B. B—e. and A.
Polypodium, L.
calcareum, Sm. A. and B—e.
connectile, W. *P. phegopteris, L.* B. A. and B—e.
hexagonopterum, Mx. A. and B—e.
vulgare, L. *Polypod.* B. A. and B—e.
Pteris, L.
aquilina, L. *Common Brake.* B. B—e. and A.
atropurpurea, L. *Rock Brake.* A.
Struthiopteris, W.
Pennsylvanica, W. A. and B.
Woodsia, R. Brown.
ilvensis, Ph. *W. rufidula, Beck.* A. and B.
Woodwardia, Smith.
angustifolia, Sm. *W. onocleoides, W.* N. B
Virginica, W. Tewksbury, Big. Malden. Curtis.

LYCOPODIACEÆ.

Lycopodium, L. *Ground Pine.*
annotinum, L. A.
apodum, L. A.
clavatum, L. *Club Moss.* B. B—e. and A.
Carolinianum, L. B.
complanatum, L. *Ground Pine.* B. B—e. and A.
dendroideum, Mx. do. B. B—e. and A.
inundatum, W. N. B.
lucidulum, Mx. *Moon Fruit Pine.* B. and A.
rupestre, L. B. B—e. and A.

TRIBE II.—MUSCOIDEÆ.

No Catalogues of the remaining orders of plants have been published in Massachusetts, except for Berkshire County and the vicinity of Amherst College, or the valley of the Connecticut. B—e, as usual, is added to those species that are found in Berkshire: and B—e * to the few that are peculiar to Berkshire. All, that have not the star annexed, occur in the Connecticut Valley, and doubtless this list falls far short of the actual number.

MUSCI.

Anictangium, Hedw.
filiforme, Hedw. *Hedwigia filiformis, P. de Beauv.* B—e.
Anomodon, Hooker and Taylor.
viticulosum, H. and T. *Neckera viticulosa, Hedw.*
Arrhenopterum, Hedw.
heterostichum, Hedw. *Byrum arrhenopterum, Dill.*
Bartramia, Hedw.
crispa? Sw. B—e.
fontana, Hooker.
gracilis, Sm. *Oederi. Schwaegrichen.*
pomiformis, Hedw.
Bryum, L.
androgynum, Hedw.
aureum.
argenteum, L. B—e.
cæspiticium, L. B—e.
cuspidatum, Schreb. B—e.
nutans, Schreb. *Webera nutans, Hedw.* B—e.
punctatum, Schreb.

- Bryum, L.
  - roseum, Schreb. B—e.
  - triquetrum, Turner. *Meesia longiseta, Hedw.*
  - turbinatum, Sw.
- Buxbaumia, L.
  - aphylla, L.
- Catharinea, Ehrh.
  - undulata, Web. and Mohr. *Polytrichum undulatum, Hedw.*
- Climacium, Web. and Mohr.
  - Americanum, Brid. *Hypnum dendroides, L.* B—e.
- Dicranum, Hedw.
  - cerviculatum, Hedw.
  - glaucum, Hedw. B—e.
  - heteromallum, Hedw. B—e.
  - orthocarpon, Hedw. B—e.
  - polycarpum, Ehrh.
  - scoparium, Hook. and Tay. B—e.
  - strictum, Brid.
  - undulatum, Ehrh.
- Diphyscium, Web. and Mohr.
  - foliosum, Web. & Mohr. *Hymenopogon heterophyllum, P. de B.*
- Didymodon, Hedw.
  - purpureum, Hooker and Tay. *Dicranum purpureum, Hedw.*
- Diplocomium, Web. and Mohr.
  - longisetum, Web. and Mohr. B—e. *Meesia longiseta.*
- Encalypta, Schreb.
  - ciliata, Hedw. Deerfield.
- Fissidens, Hedw.
  - adianthoides, Hedw.
  - taxifolius ? Hedw.
- Fontinalis, L.
  - antipyretica, L. B—e.
  - squamosa. Dr. J. Porter. Massachusetts.
- Funaria, Hedw.
  - flavicans, Muhl. B—e.
  - hygrometrica, Hedw. B—e.
- Grimmia, Hedw.
  - leucophœa, Hook. and Tay.
  - ovata ?
  - pilifera, Mx.
  - pulvinata, Smith.
- Gymnostomum, Hedw.
  - Drummondi, Hook.
  - prorepens, Hook.
  - pyriforme, Hedw.
- Hypnum, Hedw.
  - abietinum, L.
  - acuminatum, B—e. *
  - confertum, Dicks.
  - Cooleyanum, Spreng. B—e.
  - cristacastrensis, L. B—e.
  - cupressiforme, Hook. B—e.
  - cuspidatum, L.
  - denticulatum, L. B—e.
  - dimorphum, Brid.
  - filicinum, L.
  - fragile, Brid.
  - hians, Muhl.
  - imponens, Hedw. B—e.
  - lutescens, Schreb.
  - minutulum, B—e.*
  - proliferum.
  - riparium, Hook.
  - rutabulum, B—e. *

Hypnum, Hedw.
- salebrosum, B—e. *
- serpens, L. B—e.
- striatum, Schreb.
- tenax ? Hedw.
- Torreyanum, Spreng.
- triquetrum, L. B—e.

Leskea, Spreng.
- acuminata, Hedw. B—e.
- curvata, Voit. Deerfield.
- obscura, Hedw.

Leucodon, Schwaeg.
- sciuroides, Schwaeg.

Neckera, Hedw.
- minor, P. de Beauv.
- pennata, Hedw. B—e.

Orthotrichum, Hedw.
- affine, Hook. and Tay.
- anomalum, Hedw.
- clarellatum.
- crispum, Hook. and Greville.
- cupulatum, Hoffm ?
- Drummondi, Hook. & Grev.
- Hutchinsiæ, Hook. & Grev.
- pumilum, Swartz.
- speciosum.
- strangulatum, P. de Beauv.
- reticulosum.

Polytrichum, L.
- aloides, Hedw. B—e.
- alpestre, Funck. Dr. J. Porter.
- commune, L. Dr. J. Porter.
- formosum, Hedw.
- juniperinum, W. B—e.
- pallidisetum, Hook. &Taylor. Dr. J. Porter.
- perigoniale. B—e. *

Pterogonium, Sw. *Pterigynandrum, Hedw.*
- apiculatum, Brid.
- hirtellum, Hedw.
- intricatum, B—e. *
- julaceum, Hedw.
- subcapillatum, Hedw.
- trichomitrion, Swartz. B—e.

Sphagnum, L.
- acutifolium, Hook. and Tay.
- latifolium. B—e. *
- obtusifolium, Hook. *cymbifolium, Sw.*
- squarrosum, Web. and Mohr.

Tetraphis, Hedw.
- pellucida, Hedw.

Timmia, Hedw.
- cucullata, Mx. B—e.

Trematodon, Rich.
- longicollis, Rich. Deerfield.

Trichostomum, Hedw.
- pallidum, Hedw. B—e.

Weissia, Hedw.
- controversa.
- microdonta, Hedw. B—e.
- viridula, Hedw. B—e.

HEPATICÆ.

Anthoceros, L.
- levis, L.

Blasia, L.
pusilla, L. *Jungermannia blasiæ. Hook.*
Jungermannia, L.
tridentata, Schw. Dr. Porter.
complanata, L. *Plaited Moss.*
ciliaris, L. J. *sertularioides, Mx.*
dilatata, Web. Dr. Porter.
multifida, L. Do.
pinguis, L.
platyphylla, L.
porella, Dickson. Ware. Mr. Emerson Davis.
scalaris, Schwein.
sphagni, Dick. *crenulata, Hook & Tay.* Dr. Porter.
tamarisci, Martens.
tomentella, Ehrh.
trilobata, Web.
tridenticulata, Mx.
Marchantia, L. *Liverwort.*
conica, L. B—e.
crinita, Mx.
cruciata ? L. *Staurophora pulchella, W.*
polymorpha, L. *Brook Liverwort.* B—e.
triceps, Schw. MS.
Riccia, L.
fluitans, L. *Forkstems.* B—e. *
natans, L. *Floating Liverwort.* B—e.
lutea.

CHARACEÆ.

Chara, L.
flexilis, W.
foliosa, W.
vulgaris, L. *Feather Beds.*

TRIBE III.—APHYLLÆ, OR LEAFLESS FLOWERLESS PLANTS.

LICHENES.

According to Acharius, except where other authorities are mentioned.

Alectoria.
jubata. *Negro Hair.*
Arthonia.
punctiformis.
radiata.
Bæomyces, Pers.
roseus, Pers.
Borrera.
chrysophthalma. On the coast.
Calicium.
quercinum. Plainfield.
tigillare. Cummington. Dr. Porter.
Cenomyce.
allotropa.
baccillaris.
botrytes.
capitata.
coccifera.
endivœfolia.
cæspititia.
gonorega.
pyxidata.
rangiferina.
Vars. 1 sylvatica.
2 alpestris.
3 minor.
verticillata.

- Cetraria.
  - ciliaris.
  - glauca.
  - lacunosa.
  - viridis, Schw. Abington. Dr. Porter.
- Collema.
  - furvum.
  - juglandii, Schw.
  - lacerum.
  - tunæforme.
- Cornicularia, Schreb.
  - fibrillosa.
- Endocarpon, Hedw.
  - Hedwigii, Ach. Dr. Porter.
  - miniatum, B—e.
  - smaragdulum. Plainfield. Dr. Porter.
  - Weberi. do. do.
- Evernia.
  - prunastri. *Borrera purpuracea, Spreng.*
- Graphis, Adanson.
  - scripta.
- Gyrophora.
  - deusta.
  - Muhlenbergii, B—e.
  - papulosa, B—e.
  - vellea.
- Hysterium, Tode.
  - rufescens, Schw.
- Lecanora.
  - albella.
  - atra. *var.* liquatilis.
  - brunnea.
  - cæsio-rubella.
  - candellaria.
  - fulva, Schw.
  - granulosa.
  - parella.
  - salicina. Plainfield. Dr. Porter.
  - Smithii, Ach. Abington. Dr. Porter.
  - sophodes ?
  - supfusca.
  - tartarea.
  - tuberculosa.
  - varia.
  - vitellina.
- Lecidea.
  - albella, Schw: MS.
  - albo-cærulescens.
  - carneola.
  - confluens. Chesterfield. Dr, Porter.
  - demissa.
  - Ehrhartiana.
  - immersa.
  - œderi ?
  - parasema.
  - subfusca.
  - umbrina.
- Lepraria.
  - sulphurea.
- Nephroma.
  - resupinata, Spreng.
- Opegrapha.
  - macularis. Plainfield. Dr. Porter.

- Parmelia. *Shield Lichen.*
  - aipolia.
  - aleurites.
  - cæsia.
  - caperata.
  - ciliaris ?
  - colpodes.
  - corrugata.
  - crinita ?
  - cristulata.
  - cycloselis.
  - herbacea.
  - olivacea.
  - parietina.
  - perforata.
  - physodes.
  - physodoides, Schw. MS.
  - placorodia, Muhl.
  - plumbea.
  - rutilans. Plainfield. Dr. Porter.
  - saxatilis.
  - scortea.
  - stellaris.
  - tiliacea.
  - ulothrix.
  - venusta.
- Peltidea.
  - apthosa.
  - canina.
  - horizontalis.
  - scutata. *Target Lichen.*
  - venosa.
- Porina.
  - fallax.
  - papillata.
  - pertusa.
- Pyrenula, Spreng.
  - enteroleuca, Spreng. Plainfield. Dr. Porter.
- Ramalina.
  - fastigiata.
  - fraxinea.
  - polymorpha.
- Stereocaulon, Schreb.
  - paschale.
- Sticta, Schreb.
  - aurata, Smith in Rees' Cyc. Western. Dr. Porter.
  - crocata. Ashfield. Dr. Porter.
  - palmonacea.
  - scrobiculata.
  - sylvatica.
- Usnea, Schreb.
  - florida, Hoffm.
  - plicata, Hoffm.
  - strigosa. Plainfield. Dr. Porter.
- Variolaria, Pers.
  - corallina. Plainfield. Dr. Porter.
  - velata.
- Verrucaria.
  - gemmata.
  - stigmatilla. Plainfield. Dr. Porter.

FUNGI.

- Æcidium, Pers.
  - helianthi mollis ? Schw.
  - solidaginis, Schw. and many others.

Agaricus, L.
alneus, L
campestris, L. B—e.
coccineus. B—e.*
coriaceus, Bull.
disseminatus, Pers.
papyraceus. B—e.*
salignus, Pers.
trabeus ? Pers.
velutipes, Curtis. And several decades more undetermined.
Amanita, Pers.
cesareus, Schaeff.
livida ? Pers.
Arcyria, Pers.
punicea, Pers.
Boletus, L.
adustus, W. *Polyporus adustus, Fries.*
alneus, Pers. *P. cuticularis, Fr.*
badius, Pers. *P. varius, Fr.*
betulinus, Bull. *P. betulinus, Fr.*
bovinus, L.
brumalis, Pers. *P. brumalis, Fr.*
carbonarius, Schw. MS.
cinnabarinus, Jacq. *P. cinnabarinus, Fr.*
citrinus, Planer. *P. sulphureus, Fr.*
communis. B—e.*
conchifer, Schw.
delicatulus, Schw. MS.
ferrugineus.* Schaeff.
igniarius, L. B—e.
isabellinus, Schw. *P. isabellinus, Fr.*
leptocephalus, Jacq. *P. leptocephalus, Fr.*
lucidus, Curtis. *P. lucidus, Fr.*
lutans. B—e.*
mucidus, Pers. *P. mucidus, Fr.*
nigro-marginatus, Schw.
nitidus, Pers. *P. nitidus, Fr.*
perennis, L. *P. perennis, Fr.*
polycephalus, Pers. *P. umbellatus, Fr.*
ramosus, Bull. *P. imbricatus, Fr.*
reticulatus, Pers. *P. reticulatus, Fr.*
salicinus, Pers. *P. salicinus, Fr.*
sqamosus, Hudson. *P. squamosus, Fr.*
tulipiferæ, Schw.
varius, Pers. *P. varius, Fr.*
velutinus, Pers. *P. vetulinus, Fr.*
versicolor, L. *P. versicolor, Fr.*
Bovista, Dillenius.
nigrescens ? Pers. *Puff Ball.*
Cantharellus, Adanson.
pusillus, Fries.
undulatus ? Fries.
Clavaria, Vaillant.
aurantiaca, Pers.
coralloides, L.
helveloides ? Withering.
pistillaris, L.
rufa ? Muhl.
tenuis, Sowerby.
Dædalea, Pers.
albida, Schw. *Sistotrema violaceum, Pers.*
cinerea, Fries.
confragosa, Bolton.

Dædalea, Pers.
    latissima, Fries.
    quercina.
    sepiaria, Wulfen.
Fistulina, Bull.
    hepatica, Fries. *Boletus hepaticus, Pers.* Plainfield, Dr. Porter.
Fuligo, Pers.
    rufa? Pers.
Geastrum, Pers.
    hygrometricum, Pers.
    rufescens, Schaeff.
Geoglossum, Pers.
    hirsutum, Pers.
Glonium, Muhl.
    stellatum, Muhl.
Gyropodium, Schw.
    coccineum, Schw. MS. *Mitremyces lutescens, Schw. in Synopsi Fungorum Carolinæ.*
Helotium, Pers.
    aciculare? Pers. *Peziza Helot. acic. Fries.*
Helvella, L.
    albida, Bull.
    esculenta, Pers.
    mitra? L.
Himantia, Pers.
    candida, Pers.
    domestica, Pers.
Hydnum, L.
    coralloides, Scop. Conway and Ashfield.
    coriaceum, Torrey. MS.
    cyathiforme, Bull.
    gelatinosum, Scop.
    imbricatum, L.
    occarium, Batsch.
    repandum, L.
    tomentosum? L.
Hysterium, Tode.
    pulicare, Pers.
    rufescens, Schw.*
Leotia, Hill.
    chlorocephala, Schw.
Licea, Schrader.
    variabilis, Schrad.
Lycogola, Pers.
    miniata, Pers.
Lycoperdon, L. *Puff Ball. Smoke Ball.*
    bovista, Pers. non Bull. B—e.
    excipuliforme, Scop.
    molle? Pers.
    pratense, Pers.
    pyriforme, W. B—e.
Merisma, Pers.
    cristatum, Pers. *Thelephora. Meris. crist. Fries*
Merulius, Haller.
    agaricoides, Schw. MS.
    cantharellus, Pers. *Cantharellus cibarius, Fries.*
    cornucopiodes, With. *Cantharellus Corn. Fries.*
    elegans, Pers.
    tremellosus, Schrad.
Morchella, Dill.
    esculenta, Pers.

* Inserted by mistake among the Lichens.

- **Morchella, Dill.**
  - patula ? Fries.
- **Mucor, L.**
  - herbariorum, Wigg.
  - mucedo, Pers.
- **Næmaspora, Spreng.**
  - crocea, Pers.
- **Nidularia, Bull.**
  - campanulata, Sibth. *Cyathus olla, Pers.*
  - striata, Bull. *Cyathus striatus, Hoffm.*
- **Peziza, L.**
  - acetabulum, L.
  - auriformis, Schw.
  - brunnea, Fries.
  - citrina, Batsch.
  - clypeata ? Schw.
  - hemispherica, Wigg.
  - inquinans, Pers.
  - lenticularis, Bull.
  - mitrula, Schw.
  - nigrella, Pers.
  - scutellata, L.
  - umbrina, Pers.
- **Phallus, Mx.**
  - impudicus, L. B—e.
- **Physarum, Pers.**
  - cinereum, ? Pers.
- **Polyporus, Micheli.**
  - abietinus, Fries. *Sistotrema violaceum, Pers.*
  - croceus, Fries.
- **Racodium, Pers.**
  - xylostroma, Pers. *Xylostroma giganteum, Tode, Oak Leather. Punk.*
- **Rhizomorpha, Pers.**
  - subcorticalis, Micheli.
- **Scleroderma, Pers.**
  - cervinum, Pers,
- **Sclerotium, Tode.**
  - radiciforme, Schw. MS. A remarkable subterranean species. Conway
- **Sistotrema, Pers.**
  - cinereum, Pers.
- **Spermoedia, Fries.**
  - clavus, Fries. *Sclerotium Clavus, De Cand. Ergot.* B—e.
- **Sphæria, Hall.**
  - bulbosa, Pers.
  - concentrica, Tode.
  - curvirostris, Schw. MS. *non curvirostra, Sowerby.*
  - decolorans, Pers.
  - fragiformis? Pers.
  - gyrosa, Schw.
  - hypoxylon, Pers. Dr. Porter.
  - lata, Pers.
  - militaris, L.
  - nivea, Hoffm.
  - polymorpha, Pers:
  - rubiginosa, Pers.
  - scoparia, Schw.
- **Stemonitis, Gleditsch.**
  - fasciculata, Pers.
- **Thelephora, Ehrh.**
  - aurantia, Ehrh.
  - caryophylla, Schæff.

- Thelephora, Ehrh.
  - crispa, Pers.
  - fasciata, Schw.
  - ferruginea, Pers. No. 9.
  - flabellaris, Fries.
  - frustulata, Pers.
  - gigantea, Fries.
  - hirsuta, W.
  - hydnoidea, Pers.
  - incarnata, Pers.
  - lævis, Pers.
  - multipartita, Schw. MS.
  - palmata, Fries.
  - polygonia, Pers.
  - purpurea, Pers.
  - quercina, Pers.
  - rubiginosa, Schrad.
  - rugosa, Pers.
  - spadicea ? Pers.
  - terrestris, Ehrh.
  - verrucosa, Schw. MS.
- Tremella, Dill.
  - mesenterica, Retz.
- Trichia, Haller.
  - varia, Pers.
- Tubercularia, Tode.
  - castanea, Pers.
  - pezizoidea, Schw. MS.
  - rosea, Pers.
  - vulgaris, Tode.
- Tubulina, Pers.
  - fallax ? Pers.
  - fragiformis, Pers.
- Uredo, Pers.
  - caricis, Pers. *On Carex varia.*
  - flava, B—e.*
  - linearis, Lamb. *On the leaves of Oats, Rye, Wheat, &c.*
  - zeæ, Schw. *Smut on Indian Corn.*
- Xyloma, Pers.
  - acerinum, Pers.
  - andromedæ, Pers.

ALGÆ.

So far as I know, scarcely any attention has been given to this order of plants in Massachusetts.

- Conferva, L. *Frog's Spittle.*
  - fontinalis, L. et plures aliæ.
- Fucus, L.
  - nodosum, L. } On the coast with
  - vesiculosus, L. } other species.
- Laminaria.
  - saccharina, Agardh. *Kelp. Devil's Apron.*
- Lemania, Agardh.
  - fluviatilis, Agardh. Turners Falls.
- Solenia, Agardh.
  - compressa, Agardh. On the Coast.
- Spongia, L.
  - fluviatilis, L. Leverett and Chesterfield. Enumerated among the radiated animals. But most probably it is a plant.
- Sphærococus, Agardh.
  - confervoides, Agardh. On the coast.
- Ulva, L.
  - lactuca, Agardh.
  - latissima, L. On the coast, with several other species.

Summary of the Genera and Species of Plants in the preceding Catalogue.

FLOWERING PLANTS.

	Orders.	*No. Gen.*	*No. Species.*
1	Acerineae,	1	5
2	Alismaceae,	2	5
3	Amaranthaceae,	1	5
4	Anacardiaceae,	1	7
5	Amygdaleae,	2	9
6	Apocyneae,	1	3
7	Araliaceae,	2	5
8	Aristolochiae,	1	1
9	Aroideae,	6	7
10	Artocarpeae,	1	2
11	Asclepiadeae,	1	11
12	Asphodeleae,	3	4
13	Balsamineae,	1	2
14	Berberideae,	2	2
15	Betulineae,	4	11
16	Boragineae,	6	10
17	Cacteae,	1	1
18	Callitrichineae,	1	2
19	Campanulaceae,	1	3
20	Caprifoliaceae,	9	24
21	Caryophylleae,	11	26
22	Celastrineae,	1	1
23	Ceratophylleae,	1	1
24	Chenopodeae,	6	14
25	Cinchonaceae,	2	2
26	Circæaceae,	1	2
27	Cistineae,	3	7
28	Compositae,	38	150
29	Coniferae,	4	13
30	Convolvulaceae,	2	4
31	Crassulaceae,	1	1
32	Cruciferae,	15	23
33	Cucurbitaceae,	2	2
34	Cupuliferae,	4	15
35	Cyperaceae,	9	124
36	Dioscoreae,	1	1
37	Dipsaceae,	1	1
38	Droseraceae,	1	3
39	Ericeae,	11	18
40	Euphorbiaceae,	2	5
41	Fluviales,	4	12
42	Fumariaceae,	2	5
43	Gentianeae,	5	10
44	Geraniaceae,	1	3
45	Gramineae,	47	121
46	Grossulaceae,	1	8
47	Halorageae,	2	7
48	Hamamelideae,	1	1
49	Hydrocharideae,	2	2
50	Hydropeltideae,	1	1
51	Hydrophylleae,	1	2
52	Hypericineae,	1	9
53	Hypoxideae,	1	1
54	Ilicineae,	2	5
55	Illecebreae,	1	1
56	Irideae,	2	3
57	Juglandeae,	2	5
58	Juncagineae,	2	2
59	Junceae,	2	13
60	Labiatae,	22	36
61	Laurineae,	1	2
62	Leguminoseae,	17	43
63	Lentibulariae,	1	7
64	Liliaceae,	2	4
65	Lineae,	1	1
66	Lobeliaceae,	1	7
67	Loaseae,	1	1
68	Magnoliaceae,	2	2
69	Malvaceae,	4	5
70	Melastomaceae,	1	1
71	Melanthacee,	2	2
72	Menispermaceae,	1	1
73	Myriceae,	2	3
74	Nymphaeaceae,	2	3
75	Oleaceae	2	4
76	Onagrariae,	3	11
77	Orchideae,	15	32
78	Orobancheae,	2	3
79	Oxalideae,	1	3
80	Papaveraceae,	2	2
81	Phytolacceae,	1	1
82	Pistiaceae,	1	3
83	Plantagineae,	1	3
84	Plataneae,	1	1
85	Plumbagineae,	1	1
86	Podophylleae,	1	1
87	Podostomeae,	1	1
98	Polygaleae,	1	5
99	Polygoneae,	2	24
90	Pomaceae,	2	5
91	Pontederiae,	2	3
92	Portulaceae,	2	2
93	Primulacea,	6	10
94	Pyrolaceaee,	2	9
95	Ranunculaceae,	10	28
96	Restiaceae,	1	2
97	Rhamneae,	2	3
98	Rhinanthaceae,	4	5

	Orders.	*No. Gen.*	*No. Spe.*
99	Rosaceae,	10	36
100	Salicariae,	3	5
101	Salicineae,	2	22
102	Sanguisorbeae,	1	1
103	Santalaceae,	2	3
104	Sarraceniae,	1	1
105	Saxifrageae,	5	7
106	Sclerantheae,	1	1
107	Scrophularineae,	11	28
108	Smilaceae,	6	20
109	Solaneae,	6	9
110	Staphylaceae,	1	1
111	Stellatae,	1	11
112	Thymeleae,	1	1
113	Tiliaceae,	1	2
114	Typhaceae,	2	5
115	Ulmaceae,	2	3
116	Umbelliferae,	16	21
117	Urticeae,	4	8
118	Vaccineae,	2	11
119	Verbenaceae,	2	4
120	Violaceae,	1	17
121	Vites,	2	4
122	Xanthoxyleae,	1	1
123	Xyrideae.	1	1
	Whole No.	454	1246

FLOWERLESS PLANTS.

	Orders.	*No. of Genera.*	*No. of Species.*
1	Algae,	8	10
2	Characeae,	1	3
3	Equisetaceae,	1	6
4	Filices,	16	42
5	Fungi,	49	176
6	Hepaticae,	5	24
7	Lichenes,	28	110
8	Lycopodiaceae,	1	9
9	Musci,	31	110
	Whole No.	140	491

ADDENDA.

Since the preceding Catalogues were printed, an addition to the list of Birds has been received. It formed a part of a Report to the Boston Natural History Society, by C. C. Emerson Esq.

LAND BIRDS.

Muscicapa acadica, Gmel. *Small Pewee.* One of the most common summer birds, arriving from the South about the last week in April, and leaving us about the beginning of September.

Sylvia discolor, Vieill. *Prairie Warbler.* Rare in the Atlantic States: comes in May, and returns to the West Indies about the middle of September,

Sylvia Philadelphia, Wils. *Mourning Warbler.* Seen in Botanic Garden, Cambridge, by Mr. Nuttall, May 20th, 1831.

Regulus calendulus, Stephens. Bon. *Ruby-crowned Wren.* Never observed in Massachusetts in the Spring; but in October and November frequents gardens and orchards on its way to the South.

Fringilla Georgiana, Lath. *Swamp Sparrow.* Arrives in New England from the Southern States, about the middle of April.

WATER BIRDS.

Totanus Bartramius, Temm. *Bartram's Tatler.* Breeds in Massachusetts. Very common from July to August. Goes South in September,

Lestris Richardsonii, Swain. *Richardson's Jager.* Seen in the winter in the inland bays in Boston Harbor.

Anas obscura, Gmel. *Dusky Duck.* Met with from Labrador to Florida.

Fuligula fusca, Bon. *Velvet Duck.* Arrives in this vicinity from the North about the close of September.

Fuligula rubida, Bon. *Ruddy Duck.* Visits Massachusetts in October, and in the winter goes farther South.

Fuligula ferina, Stephens. *Red-headed Duck.* Appears within the limits of the United States towards the close of October: is often seen after northeast storms on the feeding bars in Massachusetts Bay.

Fuligula rufitorques, Bon. *Ring-necked Duck.* Frequent in our lakes, estuaries and rivers, at the commencement of winter.

Phalacrocorax carbo, Dumont. *Cormorant.* Found on bare rocky islands in the vicinity of Boston.

GENERAL SUMMARY

Of the Number of Animals and Plants.

	No. of Genera.	*No. of Species.*
I. Mammalia,	26	45
II. Birds,	70	157
III. Reptiles,	7	34
IV. Fishes,	57	108
V. Shells,	76	169
IV. Crustacea,	26	38
VII. Spiders,	21	125
VIII. Insects,	501	2350
IX. Radiata,	18	27
Total of Animals.	802	3153
X. Plants, (Flowering.)	454	1246
——— (Flowerless.)	140	491
Total of Plants.	594	1737

APPENDIX.

A CATALOGUE

OF SPECIMENS OF ROCKS AND MINERALS,

ILLUSTRATING THE REPORT OF A GEOLOGICAL SURVEY OF MASSACHUSETTS;

Made by Order of the Government of the State.

This collection, which I have made by direction of the State, and which I now present to its constituted authorities, can be regarded as by no means perfect. Several of the rarer and less important minerals in the State will not be found in it: nor can I flatter myself that I have obtained every variety of rock that exists in our limits. Yet have I done all in my power, during the three years that have been devoted to the geological survey, to procure a fair and full representation of our rocks and minerals. Not improbably, however, the proprietors of some of the quarries of stone in the Commonwealth, will conceive that their own are not fairly represented: for in many instances I could only procure such samples of the rock as presented themselves to my view at the quarries. But it will be easy for any who are disposed to do it, to substitute for the specimens in this collection others of a better character. And I would respectfully invite all, who feel an interest in having this collection exhibit a fair and full collection of the mineral resources of the State, to supply its deficiencies as they have opportunity. In general I have reduced the specimens to rather a small size; always intending, however, that they should fairly exhibit the characters of the rock or mineral from which they were broken. The great number of specimens which I was obliged to collect, (one suit for the Government, and one for each of the colleges in the State,) compelled me to consult utility almost entirely; and hence the collection contains little display of large and splendid specimens.

The specimens in this Catalogue are arranged in the same order as the rocks are described in the preceding Report. The specimens of the rocks are first given, and then those of the simple minerals which they contain.

About 130 of the specimens have been smoothed or polished; and this is mentioned under each number, where such is the case. Those specimens that have been only smoothed, have been varnished: and this process will need to be renewed occasionally. I found that in this way the true character of the rock could be brought to light quite as distinctly as by polishing: and thus the expense was considerably reduced.

STRATIFIED ROCKS.

Alluvium.

No.		*From*
1	Alluvial sand,	Lock's Pond, Shutesbury
2	Alluvial loam, (polishing powder,)	do
3 and 4	Peat,	Pittsfield.
5	do	Leverett.
6	do	Hadley.
7 and 8	do	Weston.
9	do	Northborough.
10	do	Shrewsbury.
11	do	Wilbraham.
12	Marl,	Pittsfield.
13	Planorbis parvus and bicarinatus in marl,	Pittsfield.
14	do trivolvis do	do
15	Lymnæa heterostropha and catascopium, do	do
16	Cyclas (*nondescript, J. M. Earl,*) in marl,	do
17	Bog Ore,	Brookfield.
18	do	New Braintree.
19	do with petrified carex,	do
20	Black Wad, (earthy oxide of manganese,)	Conway.
21	do	Leverett.
22	do	Whately.

Diluvium.

23	Diluvium,	Leominster.
24	do ferruginous,	do
25, 26, 27, and 28	do consolidated,	Pownal, Vt.
29	Pyrula Carica, (47 feet below the surface,)	Nantucket.
30	do do worn,	do
31	Natica heros,	do
32	Crepidula fornicata,	do
33	Venus castanea,	do
34	Mactra,	do

Tertiary Formations. Newest Tertiary.

35	Clay,	Amherst.
36	Sand,	do
37 and 38	Clay,	Leominster.
39	do loamy,	do
40	Sand,	do
41	Argillo-Calcareous Concretions in Clay,	South Hadley.
42, 43, and 44	do	Amherst.
45	do	Hadley.
46	do	South Hadley.
47 and 48	Organic Remains in Clay and Loam,	Deerfield.
49 and 50	do do	South Hadley Canal.
51	do do	Deerfield.
52	do do	Charlestown.
53	Brown Hematite, stalactical,	Richmond.
54	do do	West Stockbridge.
55	do pavonine,	do
56	do compact,	Richmond.
57	do mamillary,	Lenox.
58	do with yellow ochre,	West Stockbridge.
59	do with red oxide of Iron,	do
60	do with radiated manganese,	do
61	Gibbsite,	Richmond.

Plastic Clay Formation.

62 to 68	Clay of various colors,	Gay Head, Martha's Vineyard.
69 and 70	Sand agglutinated, yellow,	do
71	do white,	do
72	do green,	do

73	Sand agglutinated, with clay,	Gay Head, Martha's Vineyard.
74, 75, and 76	Lignite,	do
77	Quartzose conglomerate cemented by iron,	Gay Head
78 and 79	do cement, argillo—bituminous,	do
80	Specimen of oolitic aspect,	do
81	Indurated Clay,	do
82, 83, and 84	Impressions of Leaves on argillaceous iron ore,	do
85	Impression of a seed vessel,	do
86	Vegetable Remains,	do
87	Cast of a Venus ?	do
88	Cast of a Tellina.	do
89	Cast of a Turbo ?	do
91, 92, 93 and 94	Alcyonia ?	do
95	Unknown animal relic in ferruginous sand,	Nantucket.
96	Fossil Zoophyta in conglomerate,	Gay Head, Martha's Vineyard.
97, 98, and 99	Fossil Crabs in green sand,	do
100, 101, and 102	Sharks' teeth in green sand and conglomerate,	Gay Head.
103	Crocodiles' tooth changed into flint,	do
104 to 108	Vertebræ (104 and 107 mineralized,)	do
109	Fragment of a rib,	do
110 and 111	Fragments of bone,	do
112	do with lignite in quartzose conglomerate,	do
113, 114, 115	do in do	Gay Head.
116	do perforated	do
117 and 118	Radiated and Fibrous Pyrites,	do
119	Hydrate of Iron, pisiform,	do
120	do mamillary,	do
121	do nodular, perforated by lignite,	do
122 and 123	do do	do
124, 125, and 126	do columnar,	do
127 to 130	do compact and slaty,	do
131	Selenite in clay with lignite,	do

New Red Sandstone.

132	Conglomerate, coarse,	Greenfield.
133 and 134	do variegated,	Deerfield.
135	do of comminuted granite,	Bernardston.
136	do do	Westfield.
137	do from the ruins of argillo-micaceous slate,	Greenfield.
138 and 139	do do	Bernardston.
140	do from mica slate, talcose slate, granite, &c.	Mount Toby.
141	do do do	Mouth of Miller's river.
142	do do do epidotic	do
143	Nodule from the same conglomerate, do	do
144	Conglomerate from the ruins of granite,	South Hadley Canal.
145	do do	Mt. Holyoke.
146	do do	Belchertown.
147	do do	Amherst.
148	do with a ferruginous concretion,	South Hadley Canal.
149	do chiefly a nodule of granite,	Amherst.
150	do gray,	Turner's Falls.
151, 152, 153	Trap Conglomerate,	Mount Tom, Northampton.
285	do	do
154	Coarse Red Sandstone, (Hoyt's Quarry,)	Deerfield.
155	do	Westfield.
156	do	Whately.
157	do water worn,	Greenfield.
158	do	do
159, 160	Reddish Sandstone,	West Springfield.
161	Gray do (Hoyt's Quarry,)	Deerfield.
162	Reddish do	Westfield.
163	do do	Longmeadow.
164	do with pieces of fine red micaceous sandstone partially imbedded.	Turner's Falls.

165	Fine red Sandstone,	(smoothed,)	Longmeadow.
166	do do		do
167	Coarse gray do	from the Adit,	Southampton Lead Mine.
168	Light gray do		Mount Holyoke.
169	Darker do		Turner's Falls.
170	Variegated do	and sub-crystalline in contact with trap,	Titan's Pier, South Hadley.
171	Gray fine do		West Springfield.
172	do do		Amherst.
173	Coarser do		Turner's Falls.
174	Brecciated do		near do
175	Micaceous, gray do		South Hadley.
176	do do	under the trap,	Mt. Holyoke.
177	do do	do	Mt. Tom Northampton.
178, 179	do do		Turner's Falls.
180	do do	under the trap,	Mount Tom.
181	Amygdaloidal do	near the trap,	do
182	do do	do	Granby.
286	do		Northampton.
183	Micaceous do	passing into shale,	South Hadley.
184	do do		Sunderland Cave.
185, 186	Nodules of concretionary carbonate of lime from micaceous sandstone,		do
187	Micaceous Sandstone with carbonate of Copper,		Turner's Falls.
188	Variegated do	Agawam river,	West Springfield.
189	do do		Turner's Falls.
190	do do		South Hadley Falls.
191, 192	Red shale, slightly micaceous, divided by cross seams,		near Turner's Falls.
193	Reddish fine micaceous sandstone, under the trap,		Titan's Pier.
194, 195	do	on shale,	Turner's Falls.
196, 197, 198	do	do	South Hadley Canal
199	Shale-breaking into wedge form masses,		Turner's Falls.
200	do gray, hard, micaceous,		do
201	do yellow decomposing, (a bowlder,)		Amherst.
202, 203	do black		South Hadley Canal
204	do do		West Springfield.
205, 206, 207	Bituminous Marlite,		do
208	do		Sunderland.
209	do	variegated,	West Springfield.
210	do	glazed,	do
211, 212	Bituminous (fetid ?) Limestone,	Paine's Quarry,	do
213	Fetid Limestone, very hard and brittle,	do	do
214	do with a singular fracture resembling an organic relic,	do	do
215	do	Meachams' Quarry,	do
216	Argillo-ferruginous Limestone,	Agawam River,	do
217, 218, 219	Tripoli,	Paine's Quarry,	do
220, 221	do	South Hadley Falls, on the W. Springfield shore.	
222 to 225	Septaria or Ludus Helmontii,		West Springfield.
226, 227	Concreted Carbonate of Lime,		Mount Toby, Leverett.
228	do		Sunderland Cave.
229	do		Paine's Quarry, W. Springfield.
230	do	stalactical,	Sunderland Cave.
231	Calcareous Spar in Veins in black shale,		West Springfield.
232, 233, 234	Satin Spar in red and black shale,		do
235	Sulphate of Baryta,		below Turner's Falls, Greenfield
236	Sulphate of Strontia, on fetid carbonate of Lime,		Meachams' Quar. W. Springfield.
237	Bituminous Coal in bituminous marlite,		West Springfield.
238	do do	with blende,	do
239	Blende and Galena in fetid limestone,		do
240	Carbonate of Iron in lenticular crystals,		Turner's Falls.
241	do ?		S. Hadley Canal.
242	Iron Sand,		Turner's Falls.

243	Red Oxide of Copper in Sandstone,	Simsbury Mines, Granby, Ct.
244	Pyritous Copper in Sandstone,	Turner's Falls.
245	Green Carbonate of Copper, (poor specimen)	Greenfield.
246	Bituminous Coal in Sandstone,	South Hadley, north part.
247	do do	South Hadley Canal.
248	Anasphaltic Coal, do	Turner's Falls.
249	Incrustation of purple fluate of lime on fetid Limestone,	Paine's Quarry W. Springfield.
250 to 254	Vegetable Remains on bituminous shale, (calamites ?)	Sunderland, north part.
255	do	West Springfield.
256	do	Sunderland.
257, 258	Fucoides Shepardi in new red sandstone,	Deerfield.
259	do do	Greenfield.
260, 261	do do	Deerfield.
262, 263	Encrinite (?) in shale,	West Springfield.
264, 265	Gorgonia Jacksoni on shale,	do
266	do without reticulations,	do
267	Zoophyta (?) converted into flint in shale,	do
268 to 277	Unknown Organic Remains in fetid Limestone,	W. Springfield.
278, 279	Ichthyolites (Palaeothrissum) in bituminous shale,	Sunderland.
280	do two fish in contact,	do
281	do only scattered fragments of the fish,	do
282	Concretion (?) or Organic Relic (?) in shale,	Turner's Falls.
283	Moulds of Organic Relics (?)	South Hadley Canal.
284	Organic Relics (?) in shale: or veins of Clay,	do
285, 286	(See the numbers following 153 and 182.)	

Graywacke.

287	Conglomerate, the variety most common,	Dorchester.
288	do do	Swansey.
289	do do with a vein of quartz,	Brookline.
290	do do	Attleborough.
291	do do reddish,	Roxbury.
307	do red,	Attleborough.
292	do gray,	Natick.
293	do nodules chiefly mica slate,	Bradford.
294	do nodules fine mica slate or quartz rock, containing mag. ox. iron,	Middletown R. I.
295	do quartzose brecciated,	Attleborough.
296	Breccia, fragments of slate reunited,	Natick.
297	do do	Randolph.
298	do fine, do	Natick.
299	do fragments compact feldspar, cement indurated wacke,	Saugus.
300	Breccia, angular fragments of compact feldspar reunited,	Nantasket Beach.
301	do somewhat rounded, do slaty,	Dorchester.
302	do do do	Canton.
303	Quartz rock, dark purple quartz and mica or talc,	Middletown, R. I.
304	do do chiefly,	do
305, 306	do do with mica or talc and argillaeeous matter.	Fall River, Troy.
307	see No. following 291.	
308	Graywacke slate passing into mica slate, associated with Nos. 305 and 306.	do
309	Quartz rock, red, with red oxide of iron,	Attleborough.
311	do do	Wrentham,
312	do chocolate color,	Rehoboth.
313	do do	Walpole.
314	do do	Abington.
315	do do	Canton.
316	do do slaty,	Wrentham.
317	do do very slaty,	Randolph.

318	Quartz rock with veins of white quartz,	Wrentham.
319	do red	Greenbush, Y. N.
320	Talcose Aggregate (Steachist ?) conglomerated,	Canton.
321	do slaty,	Cambridge.
322	do do	Walpole.
323	do do	Newbury.
324	Classical graywacke, gray,	Rehoboth.
325	do reddish,	do
326	do red,	Attleborough.
327	do do (bowlder,)	Hull.
328	do gray,	Newton.
329	do with veins of quartz,	Pawtucket.
330	do with do	Stephentown, N. Y.
331	do with do	Attleborough.
332	do do	Rehoboth.
333	do with anthracite,	Troy, N Y.
334	do gray,	Stephentown, N. Y.
335	Graywacke slate, gray,	Newton.
336	do do	Watertown.
337	do do	Pawtucket.
338	do light gray,	Newbury.
339	do do glazed,	Newport, R. I.
340	do do	Watertown.
341	do do	Natick.
342	do do epidotic,	Newton.
343	do do	Taunton.
344, 345	do deep red from oxide of iron,	Attleborough.
346	do gray,	do
347	do reddish,	Newbury.
348	do do with quartz veins,	Pawtucket.
349	do do divided by cross seams,	Wrentham.
350	do do do	Pawtucket.
351	do do variegated,	Newbury.
352	do do	Milton.
353	do red (argillaceous slate ?)	Newbury, Kent's I.
354	do reddish variegated,	Hull.
355, 356	do gray,	Nassau, N. Y.
357	Novaculite,	Charlestown.
358	Argillaceous slate—coal mine,	Portsmouth, R. I.
359	do variegated,	Charlestown.
360	do rhomboidal,	Rainsford Island.
361	do do	South Boston.
362	do laminæ curved,	Rainsford Island.
363	do light gray,	Halifax.
364	Argillaceous slate with veins of calcareous spar,	Watertown.
365	do variegated,	Quincy.
366	do	Hull.
367	do (Novaculite ?)	Boston Light House.
368	do (do ?)	Hingham.
369	do (do ?)	Spring Street, Roxbury.
370	do (do ?)	Watertown.
371	Amphibolic Aggregate,	Middletown R. I.
372	Varioloid Wacke,	Saugus.
373	do	Brighton.
374	do	Hingham.
375	do	Nantasket Beach.
376	do	Hingham.
377	do nodules quartz and epidote,	Brighton.
378	do approaching to porphyry,	Needham.
379	Wacke from a vein in granite—lead mine,	Easton.
380	Aymgdaloid passing into siliceous slate,	Newport, R. I.
381	Siliceous slate, porphyritic,	do
382	do	do
383	do with vein of granite.	do
384, 385	do	Nahant.
386	Passing into Chert,	do

387	Jasper,	Newport, R. I.
387 1-2	Heliotrope,	do
388	Clouded Jasper (Compact Feldspar?) (polished)	Saugus.
389, 390	Jasper, (do?)	do
391	Prase and asbestus,	Brighton.
392	Zoisite from the amphibolic aggregate,	Middletown, R. I.
393	Cubical Pyrites in anthracitous slate,	Wrentham, coal mine.
394	Asbestus in slate,	Somerset.
395	Impressions of ferns, &c, on slate,	Newport, R. I.
396	Equisetum? on anthracitous slate,	do
397	Unknown impressions on do	do
398	Calamities,	Wrentham coal mine
399	Nevropteris? &c, on slate,	do
400	Fucoides? in hard schistose rock,	Attleborough.
401	Anthracite from graywacke,	Wrentham.
402	do do	Portsmouth, R. I.
403	See the No. following No. 803.	

Argillaceous Slate.

404	Macle in argillaceous slate, (bowlder,)	Worcester.
405	Common argillaceous slate,	Guilford, Vt.
406	do	Lancaster.
407	do	Shirley.
408	do	Harvard.
409	do	Pepperell.
410	do passing into mica slate,	Bernardston.
411, 412	do with quartz veins,	Guilford, Vt.
413	do wavy surface,	Glen, Leyden.
414, 415	do contorted,	Guilford.
416	Micaceo-argillaceous Slate, *in echellon*,	Glen, Leyden.
417	Argillaceous Slate much bent,	Guilford, Vt.
418	do do	do
419	do exhibiting a double flexure,	do
420	do red,	Sand Lake, N. Y.
421	do gray, beneath limestone,	Chatham, N. Y.
422	do epidotic,	Hancock.
423	Chloritic Slate,	Guilford, Vt.
424, 425	Passing into Novaculite,	Guilford, Vt.
426	Chiastolite in argillaceous Slate,	Lancaster.
427	A card of macles,	do

Limestone.

428, 429	White Marble, (polished)	Adams.
430, 431	do (do)	West Stockbridge.
432	do (do)	Lanesborough.
433, 434	do (do)	New Ashford.
435	White Saccharine Limestone (bowlder)	Peru.
436	Granular white dolomite,	Sheffield.
437	Gray Marble (polished)	Lanesborough.
438	do (do)	West Stockbridge.
439, 440	Gray Marble clouded (polished)	New Ashford.
441	do do (do)	West Stockbridge.
442	Dove colored Marble clouded (polished)	Great Barrington.
443	Gray Limestone,	Sheffield.
444	do	Lee.
445	do nearly compact,	Lanesborough.
446	do do	West Stockbridge.
447	do light,	Pittsfield.
448	Dark gray Limestone nearly compact,	Williamstown.
449, 450	do do	Stephentown, N. Y.
451	do	Canaan, N. Y.
452	do compact with veins of calc. spar,	Chatham, N. Y.
453	do with numerous veins of quartz,	do
454	Yellowish coarse Limestone with a foreign mineral,	Stockbridge.
455	Micaceous Limestone, mica and quartz,	do

456	Micaceous Limestone mica, and quartz,	Canaan, Ct.
457	do do	Lanesborough.
458	do do	South Lee.
459	do do	Whately.
460	do do	Colrain.
461	do do	Conway.
462	do do	Heath.
463	do do	Southampton.
464	do do with veins of quartz and calc. spar,	Conway.
465	do do with veins of granite,	Colrain.
466	do with veins of argentine,	Westhampton.
467	do decomposed at the surface,	Guilford, Vt.
468 469	Gray Limestone in Mica slate (bowlder.)	Williamsburg.
470, 471	Encrinal Limestone,	Bernardston.
472	do breciated (polished.)	do
473, 474, and 475	Disintegrating Encrini in do	do
476	Coarse white limestone with graphite (Bowlder,)	Blanford.
477 and 478	do	do
479	do	Whitingham, Vt
480	do micaceous,	do
481	do with chlorite (a bowlder, Conway,) originally from	do
482 and 483	Dolomitic (?) Limestone,	Somerset, Vt.
484	Fine granulur Dolomite,	do
485	White crystalline fetid Limestone,	Bolton.
486	Petalite,	do
487 and 488	White crystalline limestone,	Boxborough.
489	do with serpentine,	Littleton.
490	do	do
491 and 492	Coarse granular and whitish limestone,	Chelmsford.
493	do	Acton.
494	Gray do do	Walpole.
495	Compact light gray do	Newport, R. Island.
496	Compact white translucent marble (polished.)	Stoneham.
497	Granular clouded limestone,	Smithfield, R.Island
498	White do Harris Rock,	do
499	do do Dexter Rock,	do
500	Flesh colored do	do
501	Flexible Marble Slab,	New Ashford.
502	Laminated Calcareous Spar.	Bernardston.
503	Crystalline do	do
504	Hydrate of Iron,	do
505	Magnetic Oxide of Iron,	do
506	Nephrite,	Stoneham.
507	Allochroite?	do
508	Specks of Serpentine in limestone,	Boxborough.
509	Crystalline Augite in calcareous spar,	do
510	Calcareous Spar, wine yellow, in limestone,	do
511	Actynolite, in do	do
512	do radiated in do	do
513	Compact purple scapolite &c.	do
514	Lilac do	Bolton.
515	Crystallized do in gray quartz,	do
516	Dark gray do (Nuttallite)	do
517	Sahlite,	do
518	do with compact scapolite,	Acton.
519	Diopside,	Whitingham, Vt.
520	Actynolite,	Chelmsford.
521 and 522	Bisilicate of Magnesia, (Boltonite,)	Bolton.
523 and 524	White Amianthus,	Chelmsford.
525	Limestone and white talc,	Smithfield, R.Island.
526	Crystalline augite, scapolite and cinnamon stone,	Carlisle.
527	Cinnamon Stone and Pargasite,	do
528	do	do
529	Crystalized Scapolite,	Littleton.
530	Actynolite,	do

531	Phosphate of Lime in scapolite,	Littleton.
532	Sphene with scapolite and petalite,	Bolton.
533	do do	Littleton.
534	do with augite and scapolite,	Carlisle.
535	White crystalized Augite in dolomite,	Canaan, Ct.
536	Carbonate of Lime and Augite,	Lee.
537	Tremolite in Dolomite,	do.
538	do do	Canaan, Ct.
539	do	Sheffield.
539 1-2	Spinelle Pleonaste in micaceous limestone,	Acton.

Scapolite Rock.

540	Scapolite Rock somewhat crystalline,	Canaan, Ct.
541	do compact (the common variety)	do
542	do with dolomite,	do
543	do with mica passing into mica slate,	do
544	Quartz, scapolite and augite,	do

Quartz Rock.

545	White hyaline Quartz from mica slate,	Heath.
546	do do	Plainfield.
547	Whitish Quartz nearly opaque do	Saddle Mountain.
548	do do from a vein in hornblende slate,	Gill.
549	do containing argillaceous slate,	Guilford, Vt.
550	Fine white granular Quartz,	Cumberland, R. I.
551	Reddish granular do	Berkshire County.
552	do do	Cheshire.
553 and 554	Gray do	Pittsfield.
555	Dark gray do	Windsor.
556, 567 and 558	Arenaceous disintegrating Quartz,	Cheshire.
559	Granular Quartz, striped,	Conway.
560	Hyaline dark smoky Quartz,	Amherst.
561	do do in argillaceous slate.	Guilford, Vt.
562	do light smoky do	Sterling.
563	Reddish compact Quartz,	Leverett.
564	do do	Prescott.
565	Bluish compact Quartz,	Amherst.
566	Greenish do	Cumberland, R. I.
567	Porous Quartz (Buhrstone)	Washington.
568	Arenaceous Quartz with actynolite; associated with gneiss,	Pelham.
569	Gray fine granular Quartz,	Cumberland. R. I.
570	do do	Framingham.
571	Gray hyaline or coarsely granular quartz with feldspar,	Pelham.
572	Light gray granular Quartz with small scales of mica,	Lee.
573	do do stratified (Buhrstone locality)	Pittsfield.
574	The same with more mica and contorted folia,	Lee.
575	Gray hyaline quartz with mica; associated with gneiss,	New Salem.
576	Brecciated particolored quartz with mica,	Amherst.
577	Rhomboidal quartz with mica,	Northfield.
578, 579 and 580	Compact gray quartz with mica,	Bernardston.
581	Quartz and talc,	Webster.
582 and 583	do	Hawley.
584	Quartz with Actynolite connected with gneiss,	Pelham.
585	do with crystals of hornblende,	Hawley.
586	Argillaceous slate with quartz veins,	S. Hadley Canal.
587	Granular Quartz and mica, connected with gneiss,	Windsor.
588	do	Webster.
589	do associated with gneiss,	Mendon.
590	do	Webster.
591	do under the Buhrstone,	Pittsfield.
592	do	Dalton.
593	Quartz, mica and feldspar passing into gneiss,	Bernardston.
594	Quartz and mica,	Framingham.
595	do	Cumberland, R. I.

596	Quartz and mica passing into mica slate,	Zoar, at the Bridge.
597	Arenaceous quartz and mica,	Plainfield.
598	Quartz and mica vescicular,	Chesterfield.
599	do	Conway.
600	Quartz mica and feldspar, passing into gneiss,	Mendon.
601	Quartz with argillaceous slate near the lime bed,	Bernardston.
602	Brecciated Quartz,	Leverett.
603	do	Amherst.
604 605 and 606	do cement hematitic iron,	Dalton.
607	do cement iron ?	Amherst.
608	do quartz and micaceous slate,	Williamsburgh.
609	Quartzose Conglomerate (bowlder) cement mica slate,	Windsor.
610	do (do) do	Adams.
611	Quartz with disseminated iron pyrites,	Windsor.
612	do ferruginous, (bowlder)	Worthington.
613	do passing into yellow jasper,	Chesterfield.

Mica Slate.

614	Mica Slate, common, quartz laminar, mica scaly, shining,	Colrain.
615	do do do do	Peru.
616	do do do do	Blanford.
617	do do do do	Smithfield, R. I.
618	do do do do	Shelburne.
619	do do do do	Florida.
620	do do do do	Framingham.
621	do do do do	Cheshire.
622, 623	do of a fibrous aspect,	Northfield.
624	do do do do	West Stockbridge.
625	do very even and shining,	Bolton, Ct.
626	do layers tortuous, quartz tuberculous,	Stockbridge.
627	do do feldspar and quartz tuberculous, passing to gneiss,	Pittsfield.
628	do with feldspar, passing to gneiss, mica shining,	Colrain.
628	do do do do	Westfield.
630	do do do do	Leverett.
631	do do do do	Montague.
632	do do do do	Granville.
633	do do do do	do
634	do do do do	Florida.
635	do do do do	Ware.
636	do do do do	Wachusett, Princeton.
637	Talco-micaceous Slate,	Enfield.
638	do	Saddle Mountain.
639	do	Florida.
640	do	West Stockbridge.
641	do	Saddle Mountain.
642	Mica Slate, amphibolic and garnetiferous,	Norwich.
643	do do do with phosphate of lime,	Conway.
644	do do do	Colrain.
645	do garnetiferous,	Chesterfield.
646	do staurotidiferous,	do
647	do spangled,	Goshen.
648	do do	Plainfield.
649	do do rhomboidal,	do
650	do do	Norwich.
651	Argillo-micaceous Slate,	Goshen.
652	do with seams transverse to the layers,	Greenfield.
653	do rhomboidal,	do
654	do	Charlemont.
655	do	Hawley.
656	do	Heath.
657	do	Lanesborough.
658	do glazed, with quartz,	Glen, Leyden.
659	do do contorted,	Guilford, Vt.
660	do	Hancock.
661	do with undulating surface,	Bradford.
662	do contorted with layers of quartz,	Guilford, Vt.

663	Argillo-micaceous slate contorted with layers of quartz,	Whately.
664	do do	Guilford.
665	do	Bernardston.
666	do	Williamstown.
667	do	Saddle Mountain.
668	Arenaceous Mica Slate,	Norwich.
669	do passing into gneiss,	Bolton.
670	do mostly quartz, argentine locality,	Westhampton.
671	do	Norwich.
672	do vesicular (see No. 598)	Chesterfield.
673	do	Chester.
674	do	Norwich.
675	do arenaceous mica slate,	Woonsocket Falls, Cumberland, R. I.
676	do	Chester.
677	do with feldspar,	Enfield.
678	do	Chester.
679, 680	do whetstone slate,	Enfield.
681	do do	Norwich.
682	do	Sherburne.
683	do used for monuments,	Halifax, Vt.
684	do	Greenfield.
685	do with seams oblique to the surface of the layers,	Deerfield.
686	do	do
687	Argillo-arenaceous Slate, reddish, at the junction with the new red sandstone	Glen, Leyden.
688, 689, 690,	do bent,	do
691	Arenaceous Mica slate,	Worcester.
692, 693	do anthracite locality,	do
694	do with a talcose aspect,	do
695, 696, 697	do	do
698	do with veins of granite,	Lunenburg.
699, 700	do mostly quartz,	Groton.
701	Talco-arenaceous slate—bowlder,	Worcester.
702	Arenaceous Mica Slate,	Dracut.
703	do passing into clay slate,	Worcester.
704	do talcose,	Lowell.
705	do	Methuen.
706	do mostly quartz,	Worcester.
707	do	Andover Bridge.
708	do with veins of quartz,	Worcester.
709	do	Southampton, N. Hampshire.
710	do	East Sudbury.
711	do	Webster.
712	do	Oxford.
713	Plumbaginous Mica Slate, contorted,	Worcester.
714	do	Ward.
715	do	Amesbury.
716	Brecciated Mica Slate.	do
717	Anthracitous Mica Slate,	Dudley.
718, 719	do anthracite locality,	Worcester.
720	Plumbaginous Mica Slate,	Hawley.
721	do	Southampton.
722	Mica Slate, mica and quartz laminar,	Northfield, west of Ct River.
723	do do	Conway.
724	do conglomerated passing into sienite,	Whately.
725	Indurated mica slate,	do
726, 727	Augite Rock associated with mica slate,	Williamsburg.
728	Phosphate of Lime in mica slate,	Norwich.
729	Fluate of Lime,	Westmoreland, N. H.
730	White milky quartz,	Warwick.
731	Fetid hyaline quartz,	Goshen.
732	Fetid quartz, crystalized,	Williamsburg.
733, 734	Rose red quartz,	Blanford.
735	do	Chelmsford.
736	Yellow hyaline quartz,	Colrain,
736	Blood red do	do

737, 738, 739, 740, 741, 742, 743, 744	Quartzose breccia agate,	Conway.
745	do	Amherst.
746	Tabular or foliated quartz,	Conway.
747	do with a pseudo-morphous aspect,	do
748	Yellow quartz,	Amherst.
749	Fibrolite in Mica Slate,	Lancaster.
750	Sappare with phosphate of lime,	Chesterfield.
751, 752	do	do
753	do	Chester.
754	Staurotide in mica slate,	Chesterfield.
755, 756	Andalusite, crystalized,	Westford.
757	Fibrous Talc? associated with andalusite,	do
758	Schorl in quartz,	Blanford.
759, 760	Garnets in mica slate,	Chesterfield.
761	Crystalized Epidote in amphibolic mica slate,	Goshen.
762	do do	Williamsburgh.
763	Zoisite? with specular oxide of iron and carbonate of lime,	Goshen.
764	do	Chesterfield.
765	Idocrase, epidote, calcareous spar, &c.	Worcester.
766	Anthophyllite in mica slate,	Chesterfield.
767, 768	do	Blanford.
769	Cummingtonite, quartz, and garnets,	Warwick.
770	do	Cummington.
771	Black mica,	Westfield.
772	do	Norwich.
773	Fibrous talc?	Blanford.
774	Anthracite from mica slate (coal mine,)	Worcester.
775	Plumbago; or anthracite passing into plumbago,	do
1549	Amianthus, at the anthracite mine,	do
1550	Bucholzite?	do
776	Red oxide of iron from the vein of Manganese,	Conway.
777	Oxide of manganese,	do
778	do with siliceous sinter,	Amherst.
1027	Ferro-silicate of Manganese,	Hinsdale.
779	Micaceous Oxide of iron,	Montague.
780	Arsenical Iron,	Worcester.
781	Crystalized Arsenical Sulphuret of Iron,	do
782	Massive, do	do
783	Carbonate of iron,	do
784	do	Sterling.
785	do with pyritous copper,	do
786	Galena and blende,	do
787	Reddish sulphuret of Zinc,	do
788	Red Oxide of Titanium,	Conway.

Talcose Slate.

789	Scaly greenish Talc, serpentine locality,	Westfield.
790	do near the steatite,	Middlefield.
791	Foliated light green do	Rowe.
792	do	Middlefield.
793	do	Windsor.
794	Green steatite or nearly compact talc,	Zoar.
795	Steatite with rhomb spar,	do
796	do	Windsor, N. W. part.
797	do with bitter spar,	do N. E. part.
798	do with brown spar,	Smithfield, R. I.
799	do	Middlefield.
800	do bored for aqueduct pipe,	Grafton, Vt.
801	do very fine,	Blanford.
802	do	Somers, Ct.
803	do	Groton.
403 and 1548	do from gneiss,	Worcester.
804	do with asbestus,	New Salem.
805	do passing into serpentine,	do
806	Between steatite and chlorite, from a bowlder originally from Whitingham, Vt.	Conway.

807	Dark green scaly chlorite with feldspar,	Cummington.
808	Finer grained, do	Goshen.
809	Slaty Chlorite,	Smithfield, R. I.
810	do steatite Bed,	Middlefield.
811	Chlorite Slate,	Peru.
812	do with red oxide of titanium and feldspar,	Windsor.
813	Talco-chloritic Slate,	Little Compton, R. I.
814	do	Smithfield, R. I.
815	do epidotic,	Cumberland, R. I.
816	do do and passing into hornblende slate,	Smithfield, R. I.
817	Talcose Slate—talc and quartz,	Litttle Compton, R. I.
818	do do nearly white,	Stafford, Ct.
819, 820	do do do	Hawley.
821	do do greenish; soapstone quarry,	Middlefield.
822	do do do	Plainfield.
823	do do whetstone quarry,	Smithfield.
824	do do	Florida.
825	do do	Lenox.
826	Talcose Slate; talc, quartz, and mica,	Hawley.
827	do do	Iron Mine, Somerset, Vt.
828	do do	East side of serpentine, Chester.
829	do do	Barre.
830, 831	do do	Rowe.
832	Talc and Limestone,	Whitingham, Vt.
833	Talc, quartz, and Carbonate of Iron,	Hawley.
834	Quartz and Hydrate of Iron,	do
835	Talc, Quartz, and Hornblende,	do
836	do	Charlemont.
837, 838, 839	do	Hawley.
840	Talc, Quartz, and Feldspar,	Smithfield, R. I.
841	do porphyritic,	Hawley.
842	Talcose Slate, with octahedral oxide of iron,	do
843	do do	Blanford.
844	Micaceous oxide of iron,	Hawley.
844 1-2	Magnetic Oxide of Iron,	do
845	Mag. Ox. Iron, Native Magnet.	Somerset, Vt.
846	do with ferro-silicate of manganese,	Cumberland, R. I.
847	do porphyritic with crystals of feldspar,	do
848	Porous quartz with hydrate of iron, gangue of gold,	Somerset, Vt.
949, 850	do in talcose slate, do Put in the collection for comparison,	Virginia.
851	Gray oxide of manganese,	Plainfield.
852	Bisilicate of manganese,	Cummington.
853	White bitter spar,	Middlefield, Soapstone Quarry.
854	do with green foliated talc,	do
855	Salmon-colored do do	do
856	Miasite,	Zoar.
857	do?	do
858	Picrosmene?	do
859	Asbestus,	Pelham.
860	do	Blanford.
861	do	Shutesbury.
862	Tremolite, probably from the soapstone quarry,	Middlefield.
863	Fibrous hornblende in quartz,	Plainfield.
864, 865	Fasciculite in talcose slate,	do
866	Crystalized Actynolite, in talc,	Blanford.
867	do	Windsor.
868	do	from Soapstone Quarry, Blanford.
869	do radiated,	do do

Serpentine,

870	Compact noble serpentine, (polished,)	Lime Quarry, Newbury
871	do with massive garnet, [polished,]	do
872	do with green amianthus,	do
873	Common serpentine, compact,	Newbury.
874	do do	Chester, west part.
875	do do polished,	Middlefield.

876	Common Serpentine, slaty,	Chester, west part.
877	do with grains of chromate of iron,	Windsor, N. E. part.
878	do	do N. W. part.
879	do in place,	Blanford.
880	do a bowlder,	do
881	Black compact serpentine,	Newport, R. I.
882	Variegated, do	do
883	Dark green compact do a bowlder,	Leverett.
884	Dark gray compact do	Lime Quarry, Chelmsford.
885	Dark green do with veins of amianthus and Deweylite ?	Russell.
886, 887	Compact do with talcose glazing,	Zoar.
888, 889	Serpentine with steatite and brown spar,	do
890	Black do and talc or talc passing into serpentine,	New Salem.
891	do and do (polished)	Pelham.
892	Dark green do with do	Blanford.
893	Black do with do and actynolite,	Westfield.
894	Light green compact do with schiller spar ? (polished,)	Russell.
895	Black compact do with talc, and calcareous spar, (polished)	Granville.
896, 897, 898	Serpentine and carbonate of lime *Ophicalce grenue*, Al. Brongn. (polished,)	Westfield.
899	Serpentine and carbonate of lime,	Westfield.
900	Compact feldspar,	Lime Quarry, Newbury.
901	Compact Scapolite ? resembling petalite,	Westfield.
902	Mamillary Chalcedony,	Blanford.
903	Yellow Jasper.	Middlefield.
904	Chalcedony ?	do
905	Drusy Quartz,	do
906	Satin Spar,	Lime Quarry, Newbury.
907	Tremolite,	do do
908	Mussite,	Blanford.
909	Massive Garnet ?	Westfield.
910	Actynolite,	do
911	do resembling asbestus,	do
912	Chromate of iron, massive,	Blanford.
913	do in serpentine,	do

Hornblende Slate.

914	Lamellar black Hornblende (hornblende rock,)	Granville.
915	do	Belchertown.
916	do with garnets,	Norwich.
917	do	Belchertown.
918	Finer do hornblende slate,	South Hadley Canal.
919	Fibrous Hornblende, do	Enfield.
920	Somewhat granular do do	Middlefield.
921	Fibrous Hornblende, do	Leverett.
922	do do do	Florida.
923	Compact do (greenstone slate,)	Lincoln.
924	do do do	Smithfield, R. I.
925	do do do	Marlborough.
926	Fibrous do (hornblende slate,)	Shelburne.
927	do do do	Banks of Merrimack R.
928	do do do	Whately.
929	Hornblende and Feldspar,	Sudbury.
930	do do (hornblende slate,)	Bernardston.
931	do do rhomboidal, (primitive greenstone,)	Whately.
932	do do (hornblende slate,)	Ware.
933	do do compact, (transition greenstone,)	Smithfield, R. I.
934	do do not slaty, (primitive greenstone,)	Gill.
935	Quartz and feldspar, a vein in primitive greenstone,	do
936, 937, 938	Hornblende and Feldspar, primitive greenstone somewhat columnar,	Whately.
939, 940	Hornblende and Feldspar, coarsely granular, (hornblende slate.)	Ware.
941	do chiefly hornblende, (hornblende slate,)	Mouth of Miller's R.
942	do the feldspar in distinct layers, do	Dana.

943	Hornblende, Feldspar, and Mica,	Plumbago Mine, Sturbridge.
944	do porphyritic, (smoothed,)	Heath.
945	do do (bowlder,)	South Hadley Canal.
946	do do do	Amherst.
947	do and compact feldspar,	Whately.
948	do and feldspar, the latter compact and with a crystalline form,	Easton.
949	do do	Canton.
950	do do ?	Plymouth.
951	do do	Whately.
952	do and Quartz with a vein,	Becket.
953	do do with a vein of graphic granite,	Williamsburg.
954	do do	Shelburne Falls.
955	do do with a vein of quartz,	Warwick.
956	do do hornblende fibrous,	Hawley
957	do do and feldspar, the hornblende fascicular,	Conway.
958	do Feldspar, and Mica,	Amherst.
959	do with augite,	Becket.
960	do	Stow.
961	do passing into sienite,	Dracut.
962, 963	do with granite,	Leverett.
964	Hornblende and Epidote.	Granville.
964 1-2	do in contact with serpentine,	Blanford.
965	do rhombodial,	Whately.
966	Crystalized feldspar in hornblende slate,	do
967	Hornblende and Chlorite,	do
968	Actynolite Slate—actynolite, quartz, and feldspar,	Shutesbury.
969	do	Belchertown.
970	Hornblende Slate, with a layer of epidote,	Pelham.
971	Crystals of Hornblende in hornblende slate,	do

Gneiss.

972	Granitic Gneiss,	Pelham.
973	do	Templeton.
974	do	Brookfield.
975	do	New Braintree.
976	do	Pelham.
977	do	Paxton.
978	do	Petersham.
979	do granular,	Monson.
980	do	Athol.
981	do	Princeton.
982	do	Blanford.
983	Sienitic Gneiss—Gneiss with Hornblende,	Mendon.
984	Granitic Gneiss ? texture somewhat mechanical,	Bolton.
985	do	Worcester.
986	do	do
987	do chiefly flesh colored feldspar and quartz,	Sudbury.
988	do slightly talcose,	North Brookfield.
989	do somewhat schistose,	Rochester.
990	do do	Oxford.
991	do	Sudbury.
992	do (smoothed,)	Billerica.
993	Schistose Gneiss,	Dudley.
994	do	Purgatory, Sutton.
995	do granular,	Wilbraham.
996	do	Mouth of Miller's River, Montague.
997	do	Buckland.
998	do	Shelburne Falls.
999	do	Amherst.
1000	do mica predominating,	New Bedford.
1001	do passing into mica slate,	Worcester.
1002	do do	Paxton.
1003	do do	Hardwick.
1004	do	Pelham.
1005	do feldspar in tuberculous masses,	Worcester.

1006	Junction of granitic gneiss and mica slate,	Worcester.
1007	Schistose Gneiss,	Westborough.
1008	do passing into mica slate, (bowlder,)	Colrain.
1009	do	Windsor.
1010	do feldspar gray,	Little Compton, R. I.
1011	do	Monson.
1012	do chiefly feldspar,	Oxford, East part.
1013	do	Florida.
1014	do passing into mica slate with pyrope,	Western,
1015	do do	Shrewsbury.
1016	do	Western base of Wachusett, Princeton.
1017	do	Grafton.
1018	do	Charlton.
1019	do somewhat porphyritic,	Harvard.
1020	do talcose ?	Framingham.
1021	do do ?	Leverett.
1022	do do with veins of chlorite,	Bolton.
1023	Laminar Gneiss,	Windsor.
1024	do	Webster, west part.
1025	do	Amherst.
1026	do	Grafton.
1027	See the No. following No. 778.	
1028, 1029	Laminar Gneiss,	Pelham:
1030	do	Norfolk, Con.
1031	do feldspar, hornblende and slate interlaminated,	Enfield.
1032	do do	Warwick
1033	do	Savoy.
1034	do	Windsor.
1035	do	Dalton.
1036	do	Becket,
1037	do with a vein of granite,	Pelham.
1038, 1039	do	Douglas.
1040	do becoming porphyritic,	Ward.
1041	Porphyritic Gneiss,	Pelham.
1042	do feldspar, flesh colored,	Amherst.
1043	do with epidote, (smoothed,)	Pelham.
1044	do coarse.	New Braintree.
1045, 1046	do do	Ware.
1047	do	Methuen.
1048	do scarcely porphyritic,	Paxton.
1049	do	Montague.
1050	do passing into schistose,	Tolland.
1051	Amphibolic Gneiss, containing disseminated masses of hornblende,	Montague.
1052	do	Leverett.
1053	do	Enfield.
1054	do	Pelham.
1055	Epidotic Gneiss,	Amherst.
1056	do	Pelham
1057	do	Amherst.
1058	do	Grafton..
1059	do	Amherst.
1060	do ?	Duxbury.
1061	do ? containing compact feldspar,	do
1062 to 1065	Augitic Gneiss,	Lee.
1066, 1067	Anthophyllitic Gneiss.	Enfield.
1068	Arenaceous Gneiss,	Southbridge.
1069, 1070	do ?	Smithfield, R. I.
1071	Talcose Gneiss,	do
1072	Gneiss with a serpentine granite vein,	Enfield.
1073	Plumbago, the common variety,	Sturbridge.
1074	do apparently fibrous,	do
1075	do partially crystalline,	do
1076	Fuller's earth ? In the Plumbago mine,	do
1077	Hydrate of Iron, (bog ore) in do	do
1078	do do in gneiss,	North Brookfield.

1079	Garnet and Sulphuret of Molybdenum in Gneiss,	North Brookfield.
1080	Native Alum and Sulphate of Iron on gneiss,	Leominster.
1081	do do	Barre.
1082	Pyrope Garnet in gneiss,	New Braintree.
1083	do with adularia,	Brimfield.
1084	do in gneiss passing into mica slate,	Norwich, Con.
1085	Crystalized feldspar in gneiss,	Boxborough.
1086	Green Adularia, with mica (polished)	Southbridge.
1087, 1088	Adularia,	Brimfield.
1089, 1090	Schorl in quartz from gneiss,	Pelham.
1091	Crystalized Sphene in augitic gneiss,	Lee.
1092	Crystalized augite and scapolite ?	do
1093, 1094	Sulphuret of Iron,	Hubbardston.
1095	Peliom ? and pyrites,	do
1096	Magnetic Oxide of Iron in gneiss,	Grafton.
1097, 1098, 1099	Crystalized and Drusy Quartz,	Pelham.
1100	Radiated Quartz,	do
1101	Amethystine do	do
1102	Bluish Mamillary Chalcedony in gneiss,	do
1103	Breccia Agate, (polished.)	Rochester.
1104	Gray Copper, perhaps from gneiss,	Brimfield?
1105	Actynolite in feldspar,	Chelmsford.

UNSTRATIFIED ROCKS.

Greenstone.

1106	Common Greenstone,	hornblende and feldspar,	Sunderland.
1107	do	do	Deerfield.
1108	do	do	Mt. Holyoke.
1109	do	do	Turner's Falls
1110	do	do	Mt. Tom.
1111	do (Primary greenstone,)	do	Pelham.
1112	do	do epidotic,	Chelsea.
1113	do approaching to sienite	do	Newburyport.
1114	do	do	Lexington.
1115	do approaching to sienite	do	Holliston.
1116	do do	do	Concord.
1117	See the No. following 1205.		
1118	Common Greenstone, epidotic,	do	Waltham.
1119	do	do	Nahant.
1120	do	do from a vein in argilaceous slate	Charlestown.
1121	Coarse Greenstone passing into sienite,	hornblende and feldspar,	do
1122	Greenstone passing into sienite,	coarse, (a bowlder)	West Springfield.
1123	do	do	Holliston.
1124	do	do	Dover.
1125	do	do	Stoughton.
1126	do	do	Easton.
1127	do the feldspar in bronze colored folia of considerable size,		West Springfield.
1128	do	do	Mt. Holyoke.
1129	do the ingredients distinguished with difficulty,		Hingham.
1130	do	do	Newton.
1131	do passing into sienite,		Blue Hills.
1132	do		Quincy.
1133	do from a vein in gneiss,		Rutland.
1134	do		Nahant.
1135	do from a vein in gneiss,		Montague.
1136	Columnar Greenstone,	4 sided prism,	Mt. Holyoke.
1137	do	5 sided prism,	do
1138	do	3 sided prism,	do
1139	Curved exfoliation from a column,		do
1140	Compact Greenstone, the ingredients indistinct,		Nahant.
1141	do		Blue Hills.
1142	do a bowlder,		Framingham.

1143	Compact greenstone, from a vein in granite,	Foxborough.
1144	Chiefly greenish compact feldspar ?	Salisbury.
1145	do	Rowley.
1146, 1147,	do	Dedham.
1148, 1149, 1150	Indurated Clay, Titan's Pier,	South Hadley.
1151	Common Greenstone with reddish carbonate of lime,	Deerfield.
1152 to 1155	Hornblende, Augite ? and Feldspar,	Nahant.
1156	Porphyritic Greenstone, (smoothed)	Cape Ann.
1157	do	Easton.
1158	do (smoothed)	Salem.
1159	do imbedded crystals Karinthin, (smoothed)	Ipswich.
1160	do reddish,	Turner's Falls.
1161	do base reddish,	Deerfield.
1162	Greenstone porphyritic and epidotic, with iron pyrites,	Topsfield.
1163	do do base wacke-like,	Turner's Falls.
1164	do do do	Deerfield.
1165	Slaty Greenstone, micaceous,	Reading.
1166	Amygdaloidal Greenstone, nodules calcareous,	Deerfield.
1167	do nodules siliceous,	S. Hadley Canal.
1168	do nodules calcareous,	Deerfield.
1169	do do	Turner's Falls.
1170	do cavities empty, toadstone,	Gill.
1171	do do do	Mount Holyoke.
1172	do nodules siliceous,	Titan's Pier.
1173	do nodules foliated chlorite,	Turner's Falls.
1174	do nodules earthy chlorite,	West Springfield.
1175	do nodules calcareous,	Rowley.
1176	Concretion from Greenstone,	Deerfield.
1177	do	Mount Holyoke.
1178	Trap Tufa, or tufaceous greenstone,	S. Hadley Canal.
1179	do micaceous,	Deerfield.
1180	do	Titan's Pier.
1181	do cement calcareous spar,	Deerfield.
1182	do	Northampton.
1183	do	Mount Tom.
1184	do base reddish,	Deerfield.
1185	Junction of Amygdaloid and sandstone,	Turner's Falls.
1186	Trap Tufa,	West Springfield.
1187	Nodules of Prehnite in greenstone,	Greenfield.
1188, 1189	Chalcedony in do	Deerfield.
1190	do do	Greenfield.
1191	Large Agate, of chalcedony, carnelian and quartz,	Deerfield.
1192, 1193	Amethyst in greenstone,	do
1194	Black Augite, do	do
1195	Prehnite, Augite and Calcareous Spar,	do
1196	Pseudomorphous Quartz, with prehnite.	do
1197	Calcareous Spar, prehnite, &c.	do
1198, 1199	Chlorophoeite in trap,	Turner's Falls.
1200	Lincolnite and chabasie in greenstone,	Deerfield.
1201	do do	do
1202	do and chabasie do	do
1203, 1204	do covering the surface.	do
1205	Radiated mineral, perhaps Lincolnite, on greenstone,	Deerfield.
1117	Crystalized Smoky quartz, from Greenstone,	West Springfield.
1206 and 1207	Compact feldspar,	Newbury.
1208	do with talc ?	Sharon.
1209	do with dendritic impressions,	Medford.
1210	do with quartz,	Natick.
1211	do somewhat foliated, a vein in sienite,	Whately.
1212	do somewhat brecciated,	Dorchester.
1213	do do	Blue Hills.
1214	do a vein in black serpentine,	Newbury.
1215	do	Nahant.
1216	do slightly porphyritic,	Hingham.
1217	do	Lynn.

1218	Compact feldspar, somewhat foliated,		Natick.
1219	do lime quarry,		Stoneham.
1220	do variegated,		Medford.
1221	do passing into siliceous slate,		Malden.
1222	do do with a minute quantity of gold ?		Blue Hills.
1223	do red, passing into porphyry,		do
1224	do do		Hingham.
1225	do do		Milton.
1226	do do		Rowley.
1227	do do		Ipswich.
1228	do do exhibiting traces of a slaty structure, Kent's Island,		Newbury.
1229 and 1230	do variegated, somewhat foliated,		Dedham.
1231	Porphyry approaching Sienite	(polished)	Malden.
1232	do with traces of a slaty structure,		Nantasket Beach.
1233	do base purple,	(polished) bowlder,	Orleans.
1234	do base black,	do	Nantasket Beach.
1235	do approaching to amygdaloid,		Westborough.
1236	Between greenstone and porphyry,		Ipswich.
1237	do porphyry and compact feldspar,		Milton.
1238	Porphyry,		Blue Hills.
1239	Porphyry dark gray,	(polished)	Blue Hills.
1240	do do	(do)	North of Boston.
1241	do containing quartz nodules	(polished,)	Milton.
1242	do light gray	do	do
1243	do reddish,		Nantasket Beach.
1244	do ? perhaps Varioloid Wacke,		Newton.
1245	do containing quartz and feldspar crystals,		Milton.
1246	do red and green,	(smoothed)	Malden.
1247	do red with quartz and feldspar crystals, a bowlder,		Newport, R. I.
1248	do red,		Malden.
1249	do do		Lynn.
1250	do red base,		Nantasket Beach.
1251	do do	(polished)	Blue Hills.
1252	do base red	do	North of Boston.
1253	do do	do	Nantasket Beach.
1254	do greenish,	do	Malden.
1255	do lively green,	do	Milton.
1256	do		Needham.
1257	do passing into sienite,		Malden.
1258	do reddish brown, crystals of feldspar and quartz,	polished,	B. Hills.
1259	do green, passing into sienite,	(smoothed)	Malden.
1260	do base dark green, crystals feldspar and quartz	(do)	Blue Hills.
1261	do variegated, feldspar and quartz crystals	do	do
1262	do base reddish, imbedded crystals chiefly quartz	do	Quincy.
1263	do do do	do	Milton.
1264	Brecciated Porphyry, reddish,	(polished)	Halfway Rock, Atlan. Ocean.
1265	do	(smothed)	Lynn.
1266	do passing into graywacke,	do	Malden.
1267	do	(polished)	do
1268	do	do	Nantasket Beach.
1269	do greenish,		Malden.
1270	do betraying a former slaty structure,		Nantasket Beach.

Sienite.

1271	Feldspar and Hornblende,	(smoothed)	Newbury.
1272	do passing into porphyry,	do	Nahant.
1273	do	do	Stoneham.
1274	do brecciated,	do	Foxborough.
1275	do		Concord.
1276	do	(smoothed)	Dover.
1277	do	do	Reading.
1278	do	do	Nahant.
1279	do		Norfolk County.
1280	do		Rowley.

1281	Feldspar and Hornblende, Hangman's Island,	Boston Harbor.
1282	do hornblende in distinct crystals, (smoothed)	Dedham.
1283	do do	Randolph.
1284	do	Reading.
1285	do	Cumberland, R. I.
1286	do epidotic,	Dedham.
1287	Feldspar, quartz and Hornblende,	Salisbury.
1288	do	Manchester.
1289	do Quincy Granite,	Quincy.
1290	do do (smoothed)	Quincy.
1291	do (bowlder)	Mansfield.
1292	do	Franklin.
1293	do (smoothed)	Danvers.
1294, 1295	do do	Squam, Gloucester.
1296, 1297	do do	Sandy Bay, do
1298	do do	Squam, do
1299	do do	North Bridgwater.
1300	Quartz and Feldspar, do	Manchester.
1301	do do	Foxborough.
1302	do do	Easton.
1303	do feldspar mostly compact, do	West Cambridge.
1304	do do	Hingham.
1305	do do	Sherburne.
1306	do feldspar blood red, do a bowlder,	Marshfield.
1307	do and perhaps hornblende, do	Scituate.
1308	do do	Weston.
1309	do	Middleborough.
1310	do	Weston.
1311	do	Foxborough.
1312	do	Danvers
1313	Feldspar and quartz, the former compact,	Newbury.
1314	do and chlorite, the feldspar red and greenish,	Saugus.
1315	do the feldspar compact, close to the jasper,	do
1316	Passing into porphyry,	Newbury.
1317	do	Manchester.
1318	do	Malden,
1319	Feldspar, Hornblende, Quartz and Mica,	Belchertown.
1320	do (smoothed)	do
1321	do do	Northampton.
1322	do	Williamsburgh.
1323	do	Whately.
1324	do the hornblende predominating,	Northampton.
1325	do with veins of epidote,	Whately.
1326	do	do
1327	do chiefly feldspar,	do
1328	do	Gloucester.
1329	Chiefly feldspar and talc or chlorite, with veins of epidote,	Salisbury.
1330	Feldspar, hornblende ? and mica, (smoothed)	Medford.
1331	do coarse, a bowlder,	Charlestown.
1332	Feldspar, quartz, mica, and perhaps hornblende,	Fall River, Troy.
1333	Chiefly feldspar and mica,	Bradford.
1334	do with a little quartz and hornblende,	Lincoln.
1335	Feldspar, hornblende and mica,	Salem.
1336	Feldspar, hornblende, and talc,	Newbury.
1337	Feldspar, quartz, and mica, or talc,	Franklin.
1338, 1339, 1340	Granite, sienite and greenstone from the same ledge,	Stoughton.
1341	Porphyritic sienite, (smoothed)	Lexington.
1342	do feldspar and quartz with epidote (smoothed)	Marblehead.
1343	do feldspar bronze colored, do	Gloucester.
1344	do base green compact feldspar; crystals flesh red foliated feldspar; also quartz and hornblende,	West Bridgewater.
1345, 1346	do like the last.	Abington.
1347	do	Plymouth County.
1348	do feldspar, quartz, mica, and hornblende,	Essex.
1349	Porphyritic Sienite passing to porphyritic greenstone, the crystals nearly compact,	Waltham.

1350	Conglomerated Sienite,	Whately.
1351	do	do
1352	do	do
1353	do	do
1354	Junction of two varieties of sienite,	West Bridgewater.
1355	Vein of graphic granite in sienite,	Belchertown.
1356	Vein of nearly compact feldspar in sienite,	Southborough.
1357	Irregular vein of granite in sienite,	Northampton ?
1358	Vein of compact greenstone in sienite,	Nahant.
1359	Veins of feldspar in sienite,	Marblehead.
1360	Vein of compact epidote in sienite,	Abington.
1361	Vein of red feldspar in sienite,	Whately.
1362	Augite, hornblende and feldspar,	Belchertown.
1363	Augite and feldspar; the latter almost compact,	Amherst.
1364	Sulphate of baryta,	Hatfield.
1365	Purple fluate of Lime in sienite,	Cumberland, R. I.
1366, 1367, 1368	Drusy crystalized Quartz,	Whately.
1369	do with singular cavities,	do
1370	Arsenical Iron in quartz from sienite,	Newbury.
1371	Galena and Blende in sulphate of baryta,	Hatfield.

Granite.

1372	Feldspar, Quartz and mica, common granite, coarse,	Russell.
1373	do do do	Westhampton.
1374	do do do	S. Hampton Adit.
1375	do do do	Leverett.
1376, 1377	do do do	Amherst.
1378	do do do	Granville.
1379	do quartz blue, do do	Amherst.
1380	do chiefly quartz and mica, do	Westford.
1381	Feldspar, Quartz and Mica, chiefly quartz and mica,	Amherst.
1382	do do	Mouth of Miller's River.
1383	do do	Framingham.
1384	do feldspar flesh colored, do	Blanford.
1385	Feldspar, Quartz and Mica, common Granite, coarse, feldspar red,	Granville.
1386	do do do do	Amherst.
1387	do do do do	New Salem.
1388	do do do do	Concord.
1389	do quartz yellow do do	Williamsburgh.
1390	do mica yellow, do do	Chesterfield.
1391	do do do	Norwich.
1392	do in bowlders do easily decomposing,	Florida.
1393	do do quartz dark gray, inclining to purple,	Adams.
1394	do do feldspar greenish and quartz purplish,	Florida.
1395	do mica green, coarse,	Cummington.
1396	do quartz smoke gray, do	Leverett.
1397	do feldspar bluish, do	do
1398	do feldspar blue, do	do
1399	do feldspar nearly compact, do	Heath.
1400	do do do	Amherst.
1401	do (gneiss ?) do	Ashburnham.
1402	do of a mechanical aspect, do	Granville.
1403	do ingredients dark gray, do	Fall River.
1404	do (gneiss ?) do	Leominster.
1405	do do	Smithfield, R. I.
1406	do passing into sienite, rather fine,	Bristol, R. I.
1407	do junction of coarse and fine grained,	Williamsburgh.
1408	do (gneiss ?)	Top of Wachusett Mt.
1409	Quartz and mica, coarse,	Westfield.
1410, 1411, 1412	Quartz, mica and feldspar, red granite, fine grained, bowlder,	South Hadley.
1413	do feldspar red, (smoothed)	Falmouth.
1414	do do do	Rochester.

1415	Quartz, mica and feldspar, feldspar red, (smoothed)	Wareham.
1416	do reddish gray, do	Framingham.
1417, 1418	do mica black, fine grained,	Cumberland, R. I. N.E.part
1419	do perhaps sienite, do (smoothed)	Medfield.
1420	do rather fine grained,	Carver.
1421	Feldspar, Quartz and mica, or Talc, do	Weston.
1422	do do	Eastern part of the State.
1423	Feldspar, Quartz and Mica, bowlder, fine grained,	Adams,
1424	do feldspar purplish,	Belchertown.
1425	do evidently recomposed, from a vein,	Westfield.
1426	Feldspar, Quartz and Mica, fine grained, quarried,	Ashburnham.
1427	do with small garnets,	Acton.
1428	do fine grained,	Whately.
1429	do do	Conway,
1430	do do	Holliston.
1431	do chiefly quartz and feldspar,	Dedham.
1432	do do	Chester.
1433	do feldspar mostly foliated, gray, but some of it compact and greenish, quartz gray, approaching to granular, mica black, (smoothed)	Pilgrim Rock, Plymouth.
1434	do similar to the last,	do
1435	Feldspar, Quartz and Mica, fine grained,	Acton.
1436	do chiefly quartz,	Sudbury.
1437	do passing into porphyry,	Halifax.
1438	Feldspar, Quartz, and Talc?	Duxbury.
1439	Feldspar and quartz, perhaps sienite,	Newbury.
1440	Feldspar, Quartz and Mica, approaching to sienite, apparently stratified,	Worcester.
1441	do passing into mica slate,	Norwich.
1442	do do	Colrain.
1443	do mica black, resembling sienite, (smoothed)	Dover.
1444	do fine grained,	Southampton Adit.
1445	do quarried, do	Tyngsborough.
1446	do do	Norwich,
1447	do wrought, do	Dover.
1448	do mica nearly wanting, very fine grained, quarried, (smoothed)	Dover.
1449	do fine grained, bowlder,	Amherst.
1450	do quarried, (smoothed)	Concord.
1451	do feldspar reddish, mica scarcely present, (smoothed)	Waltham.
1452	do very fine grained, decomposing at the surface, (smoothed)	Sharon.
1453	do quarried, (smoothed) (Chelmsford granite)	Westford.
1454	do do do	Fitzwilliam, N. H.
1455	do do do porphyritic,	Pelham, N. H.
1456	do do do	Fitchburg.
1457	do do do	Ashby.
1458	do do do	Williamsburgh.
1459	Feldspar, Quartz and Talc,	Dedham.
1460	Feldspar, Quartz and mica, resembling sienite,	Cumberland, R. I.
1461	Feldspar, Quartz, Mica and Talc, coarse, bowlder,	Amherst.
1462	Pseudomorphous Granite,	Williamsburgh.
1463	Porphyritic Granite,	Chester.
1464	do bowlder,	Shutesbury.
1465	do very coarse,	Harvard.
1466	do fine grained, feldspar nearly compact, bowlder, (smoothed)	Turner's Falls.
1467 1468	do feldspar chiefly compact, in argillaceous slate,	Guilford, Vt.
1469 1470	Chiefly compact feldspar and quartz, do	do
1471 1472	Graphic Granite,	Williamsburgh.
1473	do	Leominster.
1474	do from a vein in quartz rock.	Washington.
1475	do	Goshen.
1476	do reddish, bowlder,	Amherst.
1477 1478	do flesh red, from red sandstone.	Deerfield.

1479	Graphic Granite.	Warwick.
1480	do with garnets,	Goshen.
1481	Junction of Granite and Mica slate,	Conway.
1482	Vein of Granite in Mica Slate,	do
1483	do do	Williamsburgh.
1484	do in the Worcester County Mica slate,	Leominster.
1485	Granite at its junction with micaceous limestone,	Conway.
1486	Granite with a nodule of mica slate, bowlder,	Deerfield.
1487 1488	Laminated and Tabular Sulphate of baryta,	Leverett.
1489	Crystalized calcareous spar, Lead Mine,	Southampton.
1490	Argentine,	Westhampton.
1491	do showing its junction with granite,	do
1492	do Lead Mine,	Southampton.
1493 1494 1495 1496	Crystalized Quartz of various colors, do	do
1497	Radiated crystalized quartz,	do
1498	Purple Quartz in granite,	Florida.
1499	Crystalized smoky Quartz,	Goshen.
1500	Massive do	Williamsburgh.
1501	Pseudemorphus Quartz, form of hogtooth spar,	Westhampton.
1502	do form of fluate of Lime,	do
1503	Hornstone, Lead Mine,	Southampton.
1504, 1505	Gray and greenish Spodumene,	Goshen.
1506	do light rose color,	do
1507	do green and translucent,	do
1508	do white and pearly,	Sterling.
1509	Straw colored Mica, Tourmaline locality,	Chesterfield,
1510	do in distinct crystals,	Goshen.
1511	Rose colored Mica, do	do
1512	Prismatic Mica,	Russell.
1513	Variegated prismatic mica,	do
1514	Black mica,	do
1515	Plumose Mica,	Williamsburgh.
1547	Schorl with terminations, in granite,	Chelmsford.
1516, 1517	Indicolite,	Goshen.
1518	do light blue,	do
1519	do or green tourmaline,	do
1520	Yellowish Green Tourmaline,	do
1521	Indicolite embraced in green tourmaline,	Chesterfield.
1522	Green, red, and blue tourmaline,	do
1523	Green tourmaline in quartz,	do
1524	do enclosing rubellite,	do
1525	Limpid Beryl in granite,	Goshen.
1526	do rose red,	do
1527	Massive Beryl with Spodumene,	do
1528	do	do
1529	Radiated mineral on granite, of the Zeolite family: probably stilbite,	do
1530	Fibrous Talc ?	Norwich.
1531	do ?	Blanford.
1532	Common feldspar,	Williamsburgh.
1533	Blue do	Leverett.
1534	Greenish do	Goshen.
1535	Siliceous do Cleavlandite, foliated,	Chesterfield.
1536	do do	New Salem.
1537	Foliated siliceous Feldspar,	Goshen.
1538	Siliceous Feldspar, coarsely granular,	Chesterfield.
1539	do finely granular,	Goshen.
1540	Galena in Quartz.	Southampton.
1541	do with Blende,	Whately.
1542	do with Carbonate of Lead,	Southampton.
1543	Blende in Quartz,	Northampton.
1544	Pyritous Copper in Quartz,	Southampton.
1545	Blende, Galena, and Pyritous Copper,	do
1546	Blende decomposing in quartz,	Williamsburgh.
1547	See the No. following No 1515.	
1548	See the No. following No. 803.	
1549	See the No. following No. 774.	
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ADDITION AND CORRECTION.

In the American Journal of Science for October, 1834, (received too late to be noticed in the proper place,) Professor Silliman has described the vertebal bone of a Mastodon in a 'tufaceous lacustrine formation,' in the town of Berlin, Conn. in the Valley of the Connecticut: And he mentions this as 'the third instance of a Mastadon bone found east of the Hudson River,' viz. a molar tooth found in Sharon, Conn. and molar teeth in Cheshire, Conn. These facts in relation to the organic remains of the diluvium of N. England, I have felt to be too important to be passed unnoticed.

In consequence of a suggestion from Mr. C. U. Shepard of New Haven, after this sheet was in type, I have been led to re-examine, with as much care as my limited time would permit, the mineral that forms the principal constituent of the Scapolite Rock described on page 315. And although I am not entirely satisfied that it is not scapolite, I am more inclined to refer it to nephrite, or perhaps to saussurite Its hardness (between feldspar and quartz,) and specific gravity (3,07 by two trials,) correspond to nephrite. Its behavior before the oxyhydrogen blowpipe is exactly like that of crystalized scapolite; both melting with intumescence into a shining enamel. Its bluish gray or white color give it the appearance of scapolite; and I have never seen any of it which exhibited the least of that greenish tinge so common in nephrite and saussurite. As to the latter mineral, I can hardly persuade myself that it is not a variety of nephrite. Beudant considers it a compact variety of albite. Are not all of these substances *metamorphic*; and does not this explain the great diversities which we find in their description among mineralogists?

If the mineral under consideration be nephrite, or saussurite, it ought probably to be regarded as a variety of the Euphotide of Hauy and Brngniart. It differs, however, in its geological position and lithological characters from that rock, as described in the books, so much as to leave one in doubt whether it should be referred to Euphotide. Yet its association with dolomite in this country, like the euphotide in Europe, favors the opinion that they were produced under similar circumstances, although not perhaps at the same epoch.

REPORT

ON A

RE-EXAMINATION

OF THE

ECONOMICAL GEOLOGY

OF

MASSACHUSETTS.

BY EDWARD HITCHCOCK,

PROFESSOR OF CHEMISTRY AND NATURAL HISTORY IN AMHERST COLLEGE.

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REPORT.

To His Excellency EDWARD EVERETT,
Governor of Massachusetts:

SIR,—The commission with which I was honored, to make a further Geological and Mineralogical survey of the State, was not received in season to enable me to enter upon the work till towards the conclusion of the last summer. From that time to the present, I have devoted myself to it almost without cessation.

I was directed to give special attention to five leading objects. The first was the collection and analysis of our soils, with a view to their improvement on chemical principles. The second was the discovery of coal, marl, and ores. The third was a re-examination of some of the rock formations, so as to determine more accurately their limits, that they may be colored on the new Geographical Map of the State. The fourth was to make further investigations into our scientific geology, both with a view to advance the science, and to make a practical application of any new discoveries that might be made. The fifth was the procuring of new specimens of our rocks and minerals for the State collection.

It was obvious at once, that it would be impossible to accomplish all these objects in one season. Indeed, in regard to the third object, which in the commencement of the geological survey was regarded as the main one, want of time was not the greatest obstacle. For it never can be effected until the geologist can obtain at least an outline map, far more accurate than any that now exists, except of one or two counties in the vicinity of Boston. It is an established principle, whose correctness will be seen on a moment's reflection, that a geological map cannot be made more accurate than the geographical one which is made its basis. Hence but little progress can be made in the third object of my commission, until the new geographical map shall be so far advanced, that I can be furnished with its outlines at least.

Under these circumstances, and agreeably to your Excellency's instructions, I have made the soils, the marls, and the ores of the State, the leading object of my labors the last season. But in doing this, it was in my power to accomplish much in respect to all the other objects above named. To collect the soils, it was necessary to visit almost every part of the State; and I have been enabled, while doing this, to trace out more accurately the boundaries of several of the rock formations; to obtain several hundred specimens for the State collection; to examine many new and deeply interesting facts illustrative of the science of geology, and to procure several new sketches of our scenery. But I am totally unprepared to report upon any part of the subject, except our economical geology*: and even here I would most gladly have delayed my report till I could have examined some localities farther, and verified the analytical results which I shall present by farther experiments. During the last season I sent a circular to every town in the State, directed generally, to some gentleman who was a member of the Legislature last year, requesting information on certain points, which would require a vast amount of time to examine personally. The prompt manner in which the gentlemen addressed have complied with my request, has been gratifying; and for the important facts which they have communicated, I feel grateful. Even up to

*In connection with specimens of our soils, marls, &c. which I have deposited in the rooms of the Boston Natural History Society with the State collection, I take the liberty to ask the attention of the government to a few specimens, illustrating our scientific geology, which I have sent to the same place, because I thought they might be interesting. Two of them (Nos. 218, 219) are examples of the tracks of animals on stone, found in the region of Connecticut river. The one which is in relief, (No. 218) is of so monstrous a size (four times larger than the track of the Ostrich) that probably many can hardly be made to believe that it exhibits only the natural size of the foot of the animal that made it. Yet I can assure them, that if they will accompany me to the banks of Connecticut river, in Northampton, I can show them six tracks of the same size, four feet apart and following one another in succession! No 219, is a smaller specimen which exhibits a very perfect example of a track in its natural position. The specimen No. 216, is a variety of the Emerald from a new locality recently discovered in Royalston. For a knowledge of this locality, as well as for assistance in obtaining specimens, I am much indebted to Alden Spooner, Esq. of Athol. It is certainly one of the finest gems which our country has produced. No. 217 is a specimen of Amethyst from Mr. Mortimer Blake of Franklin, and was found in that town. He assures me that it is much inferior to specimens which he has found there.

the time of making out this report, I have continued to receive new specimens of much interest;—some of which I have analyzed; but the localities I have not visited, both for want of time, and on account of the unfavorableness of the season of the year. As it has been impossible for me in all cases to communicate by letter, when requested, my opinion of the nature and value of the specimens sent by various gentlemen, I take the liberty to refer them for that opinion to this report, should it be printed; and also to say, that I shall take the earliest opportunity in my power to visit the localities.

In this report, I shall confine myself to those substances valuable to the State in a pecuniary point of view, *which have been discovered, or their value more fully developed, since the completion of my former Reports.* In this way the government will have a fair opportunity of judging whether this work is important enough to receive their patronage till it is completed.

1. Soils, *their Origin and Nature.*

Before proceeding to exhibit details respecting the soils of Massachusetts, it will be necessary to state my views respecting the origin and nature of soils in general, and the principles on which they may be classified.

All geologists and chemists agree in regarding soils as the result of the abrasion, disintegration, and decomposition of rocks, with the addition of certain saline, vegetable, and animal substances. Ever since the deposition of rocks, various agents have been operating upon them to wear them down, to cause them to crumble or disintegrate, and often to decompose them into their proximate or ultimate principles, while they have been constantly receiving vegetable and animal substances with soluble salts. The earthy portions, however, always constitute by far the largest part; and hence, if we know the composition of the rocks whence they were derived, we shall know the earthy and metallic constituents of the soil. Now we find that nearly all the rocks which exist in large quantity, are composed chiefly of silica, alumina, lime, and oxide of iron: and these are the ingredients that are found almost invariably in soils. Magnesia is also usually present in small quantity; as is also manganese in the soils of New England. Silica is in the largest quantity, both in the rocks and the soils; alumina next; while the other ingredients are in much smaller proportion. I ought, also, to add potassa and soda; which are very widely diffused, though not usually in large quantity. To give a numerical statement, derived from numerous analyses, such rocks as most of those in New England contain 66 per cent of silica, 16 per cent of alumina, 6 or 7 per cent of potassa, 5 per cent of oxide of iron, and of lime and magnesia a much less quantity: and the composition of our soils will probably be found to correspond very nearly with these numbers, with the exception, perhaps, of the potassa, which may have in a good measure disappeared by the operation of vegetation.

Classification of Soils.

The above ingredients are combined in different proportions in the different rocks, so as to constitute several sorts. Hence we should expect, and in fact we find, a corresponding difference in the soils resulting from their decomposition. Indeed, with some exceptions, the geologist is able to ascertain the nature of the rock from the character of the soil that covers it. And I apprehend that it will not be difficult to point out the characteristics of the soils derived from the different rock formations of Massachusetts; so that they can be distinguished by those not familiar with practical geology. This Geological Classification is the only one which I shall attempt to give of our soils; and this seems to me all that is necessary, or useful, in addition to the common division into sandy, clayey, loamy, calcareous, &c. The following list embraces, it appears to me, all the important varieties of soil in Massachusetts.

1. Alluvium, from rivers.
    Do. peaty.
2. Tertiary soil, argillaceous.
    Do. sandy.
3. Sandstone soil, red.
    Do. gray.
4. Graywacke soil, conglomerate.
    Do. slaty, gray.
    Do. slaty, red.
5. Clay slate soil.

6. Limestone soil, magnesian.
   Do. common.
7. Mica slate soil.
8. Talcose slate soil.
9. Gneiss soil, common.
   Do. ferruginous.
10. Granite soil.
11. Sienite soil.
12. Porphyry soil.
13. Greenstone soil.

A few paragraphs of explanation will, I trust, render these varieties of soil recognizable.

In general, if any one wishes to know where to find them, let him look at the Geological Map that accompanied my former Report, and he may conclude that the different soils cover those portions of the surface that are represented as occupied by the rocks from which they are derived. There is one circumstance, however, that prevents us from considering the boundaries of the rock formations as perfectly coincident with those of the soils. Diluvial action has removed nearly all the loose covering of our rocks in a southerly direction; often several miles; and more or less mingled the soils from different formations. Hence, where one formation lies north or south of another on the map, we may conclude that the detritus of the most northerly one has been swept southerly, or southeasterly, for several miles beyond the boundaries of the rock; and in few cases does the dividing line between two formations so exactly coincide with the direction of the diluvial current, that there is no overlapping and intermingling of the soil. Where the formations are limited and irregular, the soil of whole townships is of so mixed and uncertain a character, that it is hardly possible to refer it to any of the above divisions; as for example in Amherst, Ludlow, and several of the towns in Plymouth county. In such cases, it might perhaps be convenient to call the soil *diluvial:* but I have not thought it important to introduce such a variety, since it can have no constant characters, and since this difficulty is of so limited a nature. In all such cases it is better to regard the soil as a compound of detritus from the rocks lying in the vicinity to the northward.

With common alluvial soils—the result of deposition from rivers,

—every intelligent man is familiar. They are of course formed by the comminution of every kind of rock over which the stream that produces them happens to pass. These soils, I apprehend, owe their value chiefly to the fine state to which their component parts are reduced. They may be made so fine as to exclude too much the access of air: and this seems to be the case with some of the soils upon our large rivers at the West. In Massachusetts our alluvia are frequently coarse and quite siliceous.

Peat alluvium is composed principally of vegetable matter, and ought rather to be regarded as a manure than a soil. I include in it all those swamps that abound in decomposing vegetable matter, whether actually converted into peat or not.

The principal deposites of the tertiary soils are in the valley of Connecticut river, and in the counties of Plymouth, Barnstable, Dukes and Nantucket. The surface in these places is usually covered with a white or yellowish siliceous sand, which forms one variety of these soils. Where the sand is washed away, a deposite of clay is exposed; white, or whitish in the southeastern part of the state; but bluish on Connecticut river. This is the other variety of tertiary soils. Either of them in a pure state is exceedingly barren; but duly mixed, they form a very productive soil.

The sandstone soil is confined exclusively to the vicinity of Connecticut river. Most of the sandstone there is of a red color; some of it even a blood red; and its disintegration has produced a soil of the same aspect; so that even at a great distance, the redness is quite manifest. There is no soil that can easily be confounded with this, except some limited tracts of ferruginous gneiss soil in Worcester county, and of chocolate colored graywacke, and red compact feldspar, in the eastern part of the State. In a few towns, as in Granby, the sandstone soil is of a gray color, because the rock is gray beneath it.

The graywacke soil is confined to the eastern part of the State. Its color is mostly a deep brown; and it is capable of being made some of the best land in the State; as will be evident when I refer to Dorchester, Roxbury, Brookline, Newton, Cambridge, the Bridgewaters, Taunton, Middleborough, Dighton, Somerset, &c. for examples of its most perfect developement. In some of these towns the rock is chiefly a coarse conglomerate or plum pudding stone; and as this contains more calcareous matter than the slaty varieties, and decomposes more readily, probably it furnishes the best soil found over this formation. The slaty varieties occur in Quincy, Newton, Charlestown, &c. In the southwest part of Attleborough, the slate is of a chocolate color, and this peculiar hue is imparted to the soil. The same color prevails in some other places; but not extensively enough to produce any striking patches of this variety of soil.

The tracts are very limited in Massachusetts, where well characterized argillaceous or roofing slate is fully developed: and hence we have but little genuine clay slate soil. Where it does occur, as in a few towns in Worcester and Middlesex counties, also in Bernardston, in Franklin county, it has the dark color of the slate; and is easily distinguished. It is capable of being made an excellent soil.

The limestone soil is confined to the county of Berkshire. I give it this name because it lies above limestone; not because it contains more of the salts of lime than other soils in the State. For to my surprise, I find that in general it does not. Much of it probably resulted from the disintegration of the mica and talcose slates that occur in large quantities along with the limestone in that county; and probably, also, the calcareous matter, which it did once contain, has been exhausted by cultivation. The magnesian limestone and the soil thence resulting, appeared to me more extensive (though not as pure) in New Marlborough than in any other part of the county.

The mica slate soil, which occupies extensive regions in Massachusetts, as the Geological Map will show, is distinguished in appearance from the clay slate soil, chiefly by being of a lighter color. Yet since the two rocks pass into each other imperceptibly, so do these soils. And in the western part of Berkshire county, as well as in the mica slate region, extending from Worcester to the mouth of Merrimack river, the mica slate approaches so near to argillaceous slate, that the soil above it might, without much error, be referred to the latter rock. Most of our mica slate soils are of a superior quality.

The talcose slate-soil is rather limited, and not of the best quality: though it should be recollected that it occupies some of the highest parts of the State, and might at a lower level be more productive. It probably, however, contains too much magnesia. The argillo-talcose slate soils of the west part of Berkshire, are of a better quality. In appearance the mica slate and talcose slate soils can hardly be distinguished from each other; though in general the latter is of a lighter color and more sandy.

Gneiss soil occupies more surface than any other in the State: and were we to judge from its appearance, we should conclude it the poorest soil within our limits. In general, it is of a pale yellow color, and very sandy or gravelly. And, indeed, in many places it is very meagre and unproductive. But over a great part of Worcester county, for instance, it is of a very different character, being enriched probably by the potassa of the feldspar and mica in gneiss. The ferruginous gneiss soil contains so much peroxide of iron, that in some towns, as West Brookfield, Sturbridge, Brimfield, Oakham, &c., it is of a perceptible red color when seen at a distance.

Since granite and gneiss are composed of the same ingredients, the soils which they produce will not differ. And in fact they do not in Massachusetts: so that probably there is little advantage in separating them.

Sienite differs from granite in taking hornblende into its composition, as well as being in general of a finer texture. The soil resulting from its decomposition is certainly more favorable to cultivation than that derived from common granite: as an example of which I may refer to nearly the whole of Essex county.

The compact feldspar, that forms the basis of porphyry, frequently contains an unusually large proportion of alumina, from 15 to 30 per cent. And although this is the hardest of the rocks around Boston, in many places it decomposes rapidly, and the resulting soil admits of high cultivation, as may be seen in Medford and Lynn.

The greenstone in the eastern part of the State is so intimately connected with sienite and porphyry, that the attempt to separate the soils resulting from them, is almost useless. Yet the structure of the greenstone is finer, and where it predominates, we find a good soil; as in Ipswich and Woburn. The greenstone associated with sandstone, near Connecticut river, has a more earthy aspect, and produces by decomposition a peculiar yet valuable soil, of a deep brown color, and abounding in iron. It is, however, but of limited extent.

Manner of collecting specimens of the Soils.

Having adopted this arrangement of our soils, it occurred to me that the proper way to make a collection of them for analysis would be to go upon each formation, and obtain specimens from different parts of it especially where the characteristics of the soil were most clearly developed. As it was not my object to examine the soil of any particular farm, I did not even inquire from whose land I obtained the specimen: but took it where I thought the particular soil that prevailed in the vicinity was most fairly exhibited, taking care, however, to obtain specimens from every important part of the different rock formations. In nearly every instance (the few excepted cases are noticed in the results that will soon be given) I took the soil from a cultivated ploughed field; and where it was possible, from land that had been ploughed long enough for the vegetable fibres to disappear. I avoided, whenever possible, the vicinity of buildings; and especially barn yards; as I did also fields that through neglect had become very poor. As I collected these specimens in the latter part of summer, and early part of autumn, I could judge by the crops where the cultivation had been good, but not extra. I wished to avoid, on the one hand, soil that had been very much exhausted; and, on the other, that which had become quite factitious by the application of various manures and in great quantity; because I supposed a medium state of cultivation would best exhibit the real capabilities of our soils. I took the specimen three or four inches below the surface, or about half way between the surface and the sub-soil;—avoiding, as much as possible, roots, undecayed manure, and large pebbles. And in my analysis, I separated with a very coarse sieve, all the pebbles, roots, &c. larger than the tenth of an inch in diameter; and of these I made no account. For although pebbles and fragments of undecayed vegetable matters exert some influence upon cultivation, and if in large quantity may essentially modify it, yet I do not believe that a chemical examination of these matters can add any thing to what the farmer already knows on this subject.

Mode of preparing and preserving the Specimens.

The specimens as they were collected were put into tin canisters, and labelled on the spot. Afterwards they were spread upon boards and exposed for several days to a very dry air and warm sun in October. Then they were returned to the canisters. Not long after the part not used for analysis was put into white glass bottles, which were numbered and sealed. This arrangement renders them easy to be examined by the eye without the danger of being wasted by uncorking them. These bottles, to the number of 125, along with 50 others, containing marls, clays, muck sand, marsh mud, ochres, &c. with several specimens of limestones, coal, ores, &c. not previously in the State collection, are deposited in the Rooms of the Boston Natural History Society, where they can be examined by the government.

Methods of analysing Soils.

The soils being thus got in readiness for analysis, an important and difficult question arose as to the best mode of conducting that operation. The three leading objects to be attained, by such an analysis, are, first to ascertain the nature and amount of the earths that form the basis of the soils. Secondly, the nature and amount of the salts that act as stimulants to vegetation; and thirdly, to determine the amount and condition of the organic matter which constitutes the nourishment of plants. Now to accomplish all these objects, by the most accurate methods of modern analysis, is a work of so great difficulty and labor, that the time which was at my disposal between the period of collecting the soils and the meeting of the Legislature, would not have been more than sufficient to have performed it upon half a dozen specimens. Indeed, every mode of analysis that has yet been proposed, leaves many important inquiries relating to the organic matter of soils untouched and unanswered. The method proposed by Sir Humphrey Davy has long been thought the best for practical purposes; and before making trial of it, I had the same opinion: and had it answered the purpose, I was confident I should be able in a few months to apply it to all the soils I had collected. But even though the results should be such as that distinguished chemist represented: they would furnish only a very meagre account of a soil. Yet some parts of his process furnish only a very distant and uncertain approximation to the truth, as will be more fully shown further on. And it is not easy to understand how his method has been so long in such favor with almost all writers on the subject, except by supposing, that the real chemist has always seen it to be so inadequate that he has resorted to other modes when a soil was to be examined, while it is so complex and difficult that no agriculturist, who was not acquainted with chemical manipulation, and who had not access to a laboratory, has ever attempted to follow it: so that in fact, while all have recommended his rules, none have applied them. The difficulty was not that Sir Humphrey Davy did not understand all that was known on the subject when he wrote; but that in endeavoring to frame popular rules without compromitting his favorite science, he failed of his object. Still his rules do furnish results of some importance, and as I knew of no better ones which could be applied to a great number of soils within a short time, I selected a number of specimens of the different varieties of our soils, and examined them by his method considerably modified; and shall now proceed to bring the results together and inquire whether they teach any useful lesson. I should have proceeded farther in these examinations, had not a new and ingenious method of analysis been unexpectedly brought to my notice, which appeared to me much more important and satisfactory.

I ought to say, before giving the results above spoken of, that although I should not offer them if I did not suppose them accurate enough for all practical purposes, yet I do not suppose them to possess the precision that most modern analyses attain when skilfully conducted. For I was obliged to conduct a great number of these analyses together; and of course could not employ silver and platinum crucibles: nor has time been allowed me to verify the results by repeating the processes, as ought always to be done before scientific accuracy can be ensured. And the same remarks will apply, to some extent, to those other analyses which I shall present in this report: For although in all cases where it was necessary, the regular methods were employed by fusion with alkalis in silver or platinum vessels, yet no chemist who learns how numerous these analyses are, can believe it possible that they have been performed in the space of three or four months with the repetitions necessary to ensure perfect accuracy. I would gladly have made these verifications: but I have done what I could; and that work, if ever accomplished, must be future. For the alternative was before me, either to quit my laboratory, or to disappoint the expectations of government, that I should make this report during the present session of the Legislature.

Examination for Calcareous Matter in our Soils.

A preliminary step of great importance in this analysis, consisted in an examination of the soils to ascertain whether they contain lime in the state of a carbonate;—that is, common limestone. And I conducted the process in the following manner. A small quantity of the soil was introduced into a watch glass, so placed that the light from a window would fall upon it. This soil was covered with water to a considerable depth. The soil was then stirred until all the light matter and every bubble of air had risen to the top. The impurity that floated on the surface was then removed by drawing over it a piece of bibulous paper, so that the water stood perfectly clear above the soil. Then a few drops of muriatic acid were added by a dropping tube, and the water was carefully watched to see if any bubbles rose through it, as they would have done if any carbonate were present. The minutest quantity of gas escaping, could in this manner be perceived. The result disclosed the remarkable fact, that *out of one hundred and twenty-five specimens of soils from all parts of the State, and several of them from limestone tracts, only seven exhibited any effervescence;* and even these, when analysed, yielded but a very small per cent of carbonate of lime, viz:

No. 31.	Graywacke soil, Watertown,	1.3	per cent
— 51.	Limestone soil, Sheffield,	0.8	"
— 52.	Do. West Stockbridge,	3.2	"
— 78.	Gneiss soil, Westminster,	3.0	"
— 80.	Do. Fitchburg,	2.1	"
— 113.	Sienite soil, Wrentham,	0.4	"
— 125.	Greenstone soil, Deerfield,	2.0	"

Even in three of the above cases, Nos. 78, 80 and 125, I am strongly suspicious, that the calcareous matter might not have been natural to the soils. For, contrary to my usual custom, in these cases I took the specimens from small patches of cultivated ground near villages; and very likely these spots might have been manured with sea shells, or lime in some other form. Setting these aside, *only one in thirty of our soils contains any calcareous matter.* This is so different from the account given in the books of European soils, that it will doubtless be very surprising. For some of these contain more than 50 per cent of this substance; and nearly all of them a large per cent. But in our country the lack of calcareous matter is not confined to Massachusetts. In the able work of Edmund Ruffin, Esq. of Virginia, on calcareous manures, a similar statement is made respecting the soils of that State, and of some of the Western States, even in limestone regions. I have, also, recently examined five of some of the richest soils of Ohio and Illinois, and although I find calcareous matter in all but one, yet the average quantity is not over two per cent. Hence I apprehend that we shall find a deficiency of carbonate of lime to be quite characteristic of a large part of the soils of this country. This could not always have been the case, especially in limestone regions, and hence we learn—what indeed agricultural chemists now generally admit—that in cultivated fields, calcareous matter is gradually changed or consumed: and hence too we learn, what is one of the great desiderata of the soils of Massachusetts. But more of this farther on.

Results of the first mode of Analysis.

For convenience of comparison, the analyses in the following table, and indeed all that I shall give in this Report, are reduced to the same standard, viz. 100 grains; although the quantities used were sometimes more and often less. In most cases there was a loss of several grains of the soil analysed. But as I make no pretensions to great accuracy in the following results, I have thought it would prevent needless embarrassment to proportion the loss among the several ingredients of the soil.

No.	NAME AND LOCALITY OF THE SOIL.	Water of Absorption.	Organic Matter.	Siliceous Deposite from Water.	Aluminous Deposite from Water.	Salts soluble in Water.	Composition of the Aluminous Deposite.				
							Silica by Acid.	Alumina by Acid.	Alumina by Hypothesis.	Silica by Hypothesis.	Oxide of Iron.
1	Alluvial Soil; Deerfield.	3.0	5.5	29.8	61.7		55.2	3.5	18.2	40.5	3.0
2	do Northampton.	3.4	5.1	32.8	58.5	0.20	51.7	3.4	17.6	37.5	3.4
3	do Deerfield.	2.0	4.5	43.2	59.3		44.1	3.7	14.8	23.0	2.5
4	do Northampton.	3.0	3.0	74.8	19.0	0.15	16.2	1.3	5.4	12.1	1.5
5	do Northfield.	2.7	4.2	43.9	49.2		44.0	2.4	14.3	32.1	2.8
6	do Northampton.	2.1	3.2	40.0	54.7		51.0	1.7	16.3	36.4	2.0
7	do West Springfield.	1.3	5.0	67.9	25.4	0.20	21.6	1.2	7.0	15.8	2.6
8	do Stockbridge.	1.9	4.9	83.5	9.7		7.4	1.3	2.7	6.0	1.0
9	do Hadley.	4.4	6.6	45.6	43.0	0.20	39.4	1.6	12.6	28.4	2.0
10	do Sheffield.	2.2	5.5	62.1	30.0	0.20	23.9	3.0	8.3	18.6	3.1
13	Tertiary Soil, Argillaceous; Springfield.	3.3	10.0	47.8	38.7	0.16	32.7	3.5	11.2	25.0	2.5
16	do do Barnstable.	2.6	9.4	47.2	40.8	0.05	29.8	6.7	11.3	25.2	4.3
18	do Sandy; Wareham.	1.2	0.4	98.4	0.0						
19	do do Springfield.	1.7	2.7	92.8	4.8		2.4	1.3	1.1	2.6	1.1
20	do do Barnstable.	1.0	0.2	98.3	0.5				0.15	0.35	
21	do do Gloucester, (Squam.)	0.15	0.0	99.6	0.0	0.20					
23	Sandstone Soil, red; Longmeadow.	2.4	4.4	79.0	14.0	0.20	10.6	1.3	3.7	8.2	2.1
25	do do West Springfield.	2.6	6.1	50.5	40.4	0.38	32.6	4.2	11.4	25.4	3.6
26	do grey; Granby.	2.8	3.9	37.3	55.9	0.13	48.6	2.6	15.9	35.3	4.7
27	Graywacke Soil, Conglomerate; Dorchester.	3.0	7.8	61.7	27.5		19.3	4.7	7.4	16.6	3.5
30	do do Walpole.	2.2	7.6	56.0	34.1	0.10	28.5	3.1	9.8	21.8	2.5
31	do do Dighton.	1.6	5.2	59.3	33.8	0.10					
32	do Slaty; Middleborough.	1.7	6.0	69.2	23.0	0.10	17.0	2.2	6.0	13.2	3.8
35	do do Watertown.	4.1	9.1	45.6	41.0	0.20	31.9	4.1	11.1	24.9	5.0
36	do do Halifax.	1.5	5.5	82.6	10.3	0.14	6.9	2.3	2.8	6.4	1.1
38	do do Taunton.	2.0	6.0	76.4	15.5	0.10	11.1	2.8	4.3	9.6	1.6
40	do do, red; Attleboro', S. W. part.	3.2	9.7	43.0	44.0	0.12	27.5	8.0	11.8	23.7	8.5

41	Argillaceous Slate Soil; Lancaster.	3.0	9.5	59.3	28.1	0.09	23.1	3.1	9.4	16.8	1.9
43	do do Townsend.	3.5	11.5	70.5	14.2	0.32	7.2	4.5	3.6	8.1	2.5
44	Limestone Soil, Magnesian; New Marlborough.	1.9	5.8	67.6	24.6	0.12	16.6	4.0	6.4	14.2	4.0
45	do common; Lanesborough,	2.5	7.5	61.3	28.5	0.20	17.0	4.5	6.6	14.9	7.0
47	do do North Adams.	1.4	5.1	73.9	19.5	0.14	13.5	3.5	6.3	10.7	2.5
50	do do Pittsfield.	4.0	9.0	63.7	23.2	0.10	16.2	4.0	6.3	13.9	3.0
51	do do Sheffield.	3.9	7.2	67.7	20.9	0.32	11.9	5.0	4.2	12.7	4.0
54	Mica Slate Soil; Webster.	2.8	10.4	51.2	35.5	0.14	27.9	5.4	10.3	23.0	2.2
56	do Stockbridge mountain.	3.1	7.4	59.7	29.7	0.10	19.7	4.7	7.5	16.9	5.3
58	do Bradford.	3.0	10.4	44.0	42.3	0.25	32.3	5.8	12.2	25.9	4.2
59	do West Newbury.	3.0	7.6	65.2	24.1	0.10	16.2	5.1	6.6	14.7	2.8
60	do Methuen.	1.4	4.0	83.0	11.6		6.4	1.0	2.3	5.1	4.2
63	do Conway.	1.4	6.3	67.7	24.5	0.10	18.3	4.3	8.5	14.1	1.9
65	Talcose Slate; Charlemont.	2.5	6.0	72.0	19.4	0.08	12.7	1.9	4.5	10.1	4.8
67	Talco-micaceous Slate Soil; Hancock.	2.8	9.7	44.8	42.7		30.4	7.6	11.8	26.2	4.7
70	Gneiss Soil; Bolton.	2.8	7.3	63.5	26.2	0.25	22.2	2.3	7.6	16.9	1.7
71	do Uxbridge.	2.5	7.0	37.8	52.5	0.19	44.8	4.3	15.2	33.9	3.4
77	do Rutland.	3.8	10.2	58.7	27.0	0.26	21.0	3.5	7.6	16.9	2.5
79	do Royalston.	4.0	9.0	67.6	19.3	0.14	14.9	3.2	5.6	12.5	1.2
89	do Grafton.	3.0	7.7	40.1	49.0	0.20	38.9	6.7	14.9	30.7	3.4
90	do Brimfield.	2.1	6.9	70.9	20.0	0.10	15.9	2.9	5.8	13.0	1.2
93	do Becket.	4.0	9.0	64.6	22.0	0.40	16.6	3.4	6.2	13.8	2.0
96	do Sturbridge.	1.8	5.7	77.1	15.2	0.22	11.3	2.3	9.4	4.2	1.6
104	Granite Soil; Andover.	3.3	9.5	54.4	32.6	0.20	26.9	3.9	9.5	21.3	1.8
106	Sienite Soil; Marblehead.	3.7	8.9	61.5	25.8	0.10	20.0	2.3	6.9	15.4	3.5
108	do Gloucester.	1.7	4.8	80.0	13.4	0.13	9.6	2.1	3.6	8.1	1.7
109	do Lexington.	3.7	10.0	46.7	39.4	0.16	34.0	3.0	11.5	25.5	2.4
111	do Newbury.	3.5	7.5	60.1	28.8	0.12	22.2	4.4	8.2	18.4	2.2
112	do Dedham.	4.3	9.9	46.3	39.3	0.17	31.4	5.1	13.5	23.0	2.8
117	do Marshfield.	2.0	5.2	68.7	24.0	0.11	19.2	2.7	6.8	15.1	2.1
120	Porphyry Soil; Medford.	4.1	10.6	51.9	33.2	0.15	27.7	3.5	9.6	21.6	2.0
122	do Lynn.	4.0	8.5	46.4	40.8	0.30	34.6	3.7	11.8	26.5	2.5
124	Greenstone Soil; Woburn.	4.0	10.3	46.7	38.9	0.15	33.7	2.3	11.1	24.9	2.9
125	do Deerfield.	2.0	7.0	32.7	58.2	0.10	50.5	3.3	16.6	37.2	4.4

Explanation of the preceding Table with Remarks.

The numbers in the first column of the preceding table, denote the specimens of the soils deposited in the State collection: and the second column points out the name and locality.

However thoroughly soils are dried in the sun, a quantity of water still adheres to them, which cannot be entirely driven off, until they are heated to nearly 300° of Fahrenheit's thermometer; or to the point where paper begins to turn brown. This was the way in which the numbers in the third column were obtained, by heating 100 grains to that point and noting the loss of weight. Highly siliceous soils retain but very little of this water of absorption, while from highly aluminous ones, it is not all driven off by heating to 300°. The power of soils to retain water, however, depends much more upon the quantity and character of the organic matter which they contain, than upon their mineral composition, as I shall endeavor to show hereafter.

After driving off the water of absorption, the soil was heated to redness, and continued in that state until every thing combustible was burnt off. The loss of weight showed the quantity of organic matter; and thus the fourth column was formed.

Thus, if we follow the ordinary rules, we get rid at once of the most complicated and valuable part of soils, viz. the nourishment which they contain for sustaining vegetation: and in this respect the common modes of analysis are probably the most deficient. True, in this way, we get the quantity of vegetable and animal matter which a soil contains. But every farmer knows that his land may abound in such matter, and yet be almost entirely unproductive: as for instance, if it be filled with unchanged peaty matter from the swamps. He also knows that a field may contain but little organic matter, and yet be very productive, although soon exhausted. He knows, likewise, that the same quantity of manure on different fields will render the soil productive on some of them much longer than on others. Hence we learn that the most important point in this part of analysis is to determine in what state the organic matter is; whether in such a condition that it will at once afford nourishment to vegetation, or not until it has undergone a chemical change; and whether it is in such a state as to be liable to be dissipated by the common action of moisture, heat, and cold; or so fixed as to be permanent. Yet the methods of analysis given in the books, furnish no rules for deciding these points. This deficiency however, in my opinion, has been at length supplied by a chemical friend, and will be exhibited in the sequel.

The fourth column in the above table presents one fact worthy of notice. It seems that our alluvial soils, although deservedly celebrated, contain less of organic matter than almost any other in the State. The principles above suggested explain their fertility in consistency with this fact: but it shows us, if I mistake not, that such soils, if not constantly supplied with manures, either by the overflowing of rivers, or by the farmer, will be sooner exhausted than almost any others.

The numbers in the fifth and sixth columns were obtained in the following manner. One hundred grains of the soil were boiled a short time in a glass flask in water, and after cooling, this was agitated until the soil was all diffused through the water. As soon as the agitation of the water had ceased, it was poured off along with the finer parts of the soil that did not settle at once. The portion that remained usually consisted of siliceous sand, while that which was left suspended in the water, was much more aluminous, and constituted the finer and most important part of the soil. In the present instance, this deposite is in larger proportion than is usual in analysis, because it was poured off immediately after the agitation had ceased, under an impression that by waiting two or three minutes, as is usual, other and more important substances than silica may settle to the bottom of the vessel. Indeed, I found this to be the case in some instances when the light matter was poured off immediately. Thus, the red sandstone soil, No. 23, from Longmeadow, gave only 14 grains of aluminous matter, and 79 grains of siliceous. By digestion in acid, the 14 grains yielded only 1.3 gr. of alumina and 2.1 gr. oxide of iron. But by treating the 79 grains of siliceous matter in the same way, it produced 7.5 grains of alumina and 4 grains peroxide of iron. Such cases teach us that this mechanical separation of the siliceous and aluminous matter is not a little uncertain: although in general it must be confessed, that when the lighter part was poured off immediately, the remainder was chiefly siliceous sand.

It is not the object of this process however, to show us the quantity of silica and alumina in a soil: but rather the amount of finely divided matter. For the best soils are found, in general, to abound in such matter: although it may become excessive, rendering the soil impervious to air and moisture. This is a principal defect in highly argillaceous soils. But from the preceding table it appears, in my opinion, that the soils in Massachusetts are in general too coarse rather than too fine. Being derived chiefly from primitive rocks, they resist comminution and decomposition more than the secondary rocks. I am satisfied that the principal excellence of our alluvial soils depends more upon their finely divided state than any thing else: for, as I have already in part shown, and shall show farther in the sequel, they must yield in value in some important respects, to our upland soils. And even as to their fineness, they are much coarser than many of the rich alluvia of the Western States; though it may be doubted whether for most crops they are on this account the less valuable.

The term salt, in chemistry, has a much more extended meaning than in popular language. Thus common limestone (carbonate of lime) and gypsum (sulphate of lime) are properly denominated salts, as is also phosphate of lime and chloride of calcium (muriate of lime). All compounds of any acid with lime, magnesia, alumina, potassa, soda, &c. or of chlorine with their metallic basis are salts: and some of these are soluble and some insoluble in water. If any of the former exist in soils therefore, they will be dissolved, if the soil be boiled in water. And if afterwards this water be evaporated, the salt can be obtained in a dry state and weighed. This is the way in which column seventh was filled. Tests were also applied to the solutions, in order to ascertain the nature of these salts. Hydrocyanate of potassa, infusion of nutgalls, the chlorides of calcium and magnesium, and the carbonate of ammonia and phosphate of soda gave no precipitate in any instance. Hence I infer the absence of iron and the salts of magnesia. But nitrate of silver, baryta water, nitrate and acetate of baryta, and oxalate of ammonia, gave precipitates more or less abundant in every instance in which I tried them. I hence infer the presence of a sulphate, probably the sulphate of lime, in all the soils of Massachusetts that I have examined, and I have no doubt but it exists in every one of our soils. The quantity given in the table, is probably much less than the truth, for the sulphate of lime is but slightly soluble in water, and the quantity of water which I employed, was too small to dissolve all that exists in 100 grains; or rather 200 grains, which was the quantity usually boiled. It was chiefly to ascertain the fact of its existence that the experiments were performed; since I had adopted a better methed for ascertaining its quantity. This salt exists, also, probably in nearly all the springs, rivers, and ponds in the state. The great importance of gypsum, in the process of vegetation, furnishes a reason for its universal diffusion.

The four remaining columns of the table exhibit the composition of the aluminous deposite in the sixth column. That deposite was boiled two or three hours in sulphuric, or hydrochloric acid, and the alumina and iron were precipitated together by carbonate of ammonia, and afterwards separated by hydrate of potassa. The portion remaining undissolved by the acid, was considered as silica. This separation of alumina and iron by boiling in acid, is the method directed by Sir Humphrey Davy; yet it is entirely insufficient. The greater part of the iron is probably thus separated; but not so the alumina. Not half of this is generally taken up by the acid. The true and effectual way of doing this is by fusion with a carbonated alkali, in a platinum crucible. In this way, in a few instances, I treated the silica that remained after the action of the acid, and obtained the following results. The second column contains the aluminous deposite from water to be examined; the third, the alumina separated by boiling in acid, as in the table; the fourth, the alumina obtained by the process with carbonate of soda, added to that by acids; the fifth, the remaining silica after the action of acids; the sixth, the silica obtained by the alkali; and the last, the per cent of alumina in the aluminous deposite.

No.	Aluminous Deposite.	Alumina by Acids.	Alumina by Alkali.	Silica by Acids.	Silica by Alkali.	Alumina per cent.	
2	58.5	3.4	17.6	51.0	37.5	30.1	30.9 Mean.
40	44.0	8.0	11.8	27.5	23.7	26.8	
41	28.1	3.1	9.4	23.1	16.8	33.6	
47	19.5	3.5	6.3	13.5	10.7	32.3	
58	42.3	5.8	12.2	32.3	25.9	28.8	
89	49.0	6.7	14.9	38.9	30.7	30.4	
112	39.3	5.1	13.	31.3	23.0	34.3	

The small differences in the last column of the above table, between the alumina per cent, in the different specimens, suggested the idea, that by taking the mean result as a standard, an approximate estimate of the real quantity of alumina and silica, in all the aluminous deposites given in the general table, might be obtained, by simply multiplying those deposites, after subtracting the amount of iron, by that mean. In this way were the tenth and eleventh columns of the general table obtained. I have little doubt but they give the amount of alumina and silica in the finer part of the soils, within a few per cent, and accurately enough for all the common purposes of agriculture; although this is not a very scientific way of obtaining the results. Nor should I have adopted it, had time permitted me to analyse all the specimens by alkali, in the dry way,—the only way that will satisfy the chemist. By the time I had proceeded thus far in the analysis which I am describing, I became quite convinced that to obtain the exact quantity of silica and alumina in a soil, is a matter of very little importance in an agricultural point of view. I know that a soil consisting wholly of one kind of earth, will be barren; yet if a soil be finely divided it may consist mostly of one sort of earth, and yet, by proper cultivation, be rendered fertile. The proportions of silica and alumina may vary widely, and yet the power of producing plants remain essentially the same. And even where a soil is extremely siliceous or aluminous, some modifications in the mode of treating it will make it fertile. It hardly needs a chemical analysis to teach us when a soil is siliceous or aluminous.

I am satisfied, however, that the agency of the oxides of iron in agriculture has been underrated, and that a determination of the precise quantity of this substance which exists in all our soils, may be important.

These views are confirmed by the opinion of gentlemen distinguished for their accurate and practical acquaintance with chemistry. I will quote here only the opinion of A. A. Hayes, Esq., of Roxbury, as I shall soon have occasion to present, in another connection, the views of another gentleman, which, as well as those of Mr Hayes, will always command great respect. The latter, speaking of the earthy composition of soils in general, says, "I do not think that minute analyses of the earthy constituents of soils, have the valuable practical bearing which careful comparative results possess. With a fondness for observing influences, considered as minute, I should hesitate, with even such a bias, to attribute to chemical composition, so far as the earths are concerned, observed qualities in soils of great importance to cultivation; and am now strongly of the opinion, that those examinations which you propose making, will not only show our farmers the light of new knowledge, but confer on them a practical benefit, in teaching the proper modes of improving soils."*

In examining the table of analyses, above presented, it should be recollected, that the amount of alumina given, is only that which exists in the finely divided portion of the soil that remained suspended in water after agitation. In a single case, which I have already stated, the siliceous residuum was found to contain more iron and alumina than the aluminous part. But this was a peculiar case; and in general, the siliceous deposite contains little but siliceous sand. Still, where it contains fragments of feldspar, mica, &c., analysis will produce alumina and iron, although they must be in such a state as to operate upon cultivation just like siliceous sand, until decomposition begins. I have made only a single analysis to determine the quantity of alumina and iron in 100 grains of the entire soil; viz. No. 15, a tertiary argillaceous soil from Plymouth. I should expect in this specimen that both these ingredients would be above the average quantity in the soils of the State. The following is the result.

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* I trust Mr. Hayes will excuse the liberty I have here taken in quoting from a private letter.

Water of absorption	2.7
Organic matter	6.0
Oxide of iron	6.5
Salts soluble in water.	0.4
Alumina	19.2
Silica	65.2
	100

The degree of fineness in a soil is undoubtedly a matter of much importance: and fortunately the means of determining this point are within the reach of every farmer, in the manner already described. Since silica and alumina are quite inert in their properties, and enter but in small quantity into the composition of plants, it is probable that the one may to a great extent be substituted for the others without affecting the vegetation, provided they be reduced to the proper degree of fineness. On this point I am happy to quote a paragraph from Mr. Hayes, in which he gives his views of the process for alumina by Sir Humphrey Davy, which has been already described.

"The process of Sir Humphrey Davy for dissolving alumina in sulphuric acid," says he, "is by no means exact. It was his intention evidently, to dissolve in that agent, the alumina of any easily decomposable mineral existing in the finer parts of a soil; and in this application it is of value. Supposing we are operating on a white clay from Gay Head. Sulphuric acid, of the degree of 1.30, will dissolve at 60° F. a certain small portion of alumina and set free some hydrate of silica; traces of potash will also exist in the fluid. If the well washed residue, be boiled for two hours in like acid, another portion of alumina will be dissolved. By subsequently mixing the residue with concentrated sulphuric acid, and gradually heating the mass to 600° F. another quantity of the same base is taken up; and after water has removed all soluble matter the basic sulphate of alumina will, in a few weeks, cause the residue to effloresce. These effects are all referable to the state of aggregation of the particles, not only as regards fineness of powder, but permeability of structure. In soils it is probable that *the hydrates of the earths, as such, do not exist;* for we find always that a relatively electro-positive body appears when we dissolve them. As the influence of the earths is most important to vegetation, in supplying the fluid favorable to its support, may not the greater or less degree of fineness of one of the constituents of a soil materially change its nature? The process of absorption and retention may be so much modified by comminution, that I think a silico-ferruginous soil may assume the characters of an aluminous soil to a certain extent, and that the existence of a due proportion of finely divided matter is of more consequence than is its composition."

But even though the quantity of the earthy constituents of a soil may vary considerably without affecting its fertility, yet this isby no means the case with its other constituents, the salts and organic matter. The salts especially, admit of but little variation without producing sterility, either by their deficiency or excess; and hence to determine their amount, is an important point in agricultural chemistry. And the differences which are so obvious in soils derived from different rocks, do not depend entirely upon the different proportions of the earths which they contain. For the quantity and nature of the salts resulting from the decomposition of rocks are considerably different. Thus, we should expect that the gneiss and granite soils would contain a larger amount than usual of the salts of potassa, and where sulphuret of iron prevails, of the salts of iron: the porphyry soils, of the salts of soda: the graywacke and sandstone soils, of the salts of lime, magnesia and perhaps potassa, and soda; the mica slate soils, of the salts of magnesia and potassa; the talcose slate soil, of the salts of magnesia: or perhaps more commonly we should find the lime and magnesia uncombined with an acid. Such differences as these in the constituents of soils, will unquestionably affect their fertility; and it would be desirable to ascertain how far they exist in the soils of Massachusetts. I had hoped to accomplish this object: but it will require a great number of delicate and accurate analyses, demanding far more time than has yet been allowed me. As will be seen in the sequel, I have attempted to determine the amount of the salts of lime in all the soils that I have collected; but it will need comparative trials by the ordinary modes of analysis, before the peculiar characteristics of the different classes of our soils can be pointed out; and besides, I have made no attempt to determine the existence and amount of potassa and soda in my specimens. In several of the analyses, whose results are given in the preceding general table, I determined the existence and amount of pure lime: but the results appear to me of too little importance to give in detail; especially as I shall soon give, what I consider more important results of a similar character, obtained in another way. It is worth stating, however, that in all cases in which a test was applied to the solvent of the soils, it showed the presence of lime; though, as has been stated, very few specimens contained any of the carbonate of lime. In nearly every case, also, I found magnesia to be present. In the following instances I determined its amount, which, it will be seen, is small, and probably, therefore, of little consequence in an agricultural point of view.

No. 1.	Magnesia	per cent	0.66,	alluvial soil,	Deerfield.
2.	“	“	0.57	“	Northampton.
3.	“	“	0.01	“	Deerfield.
4.	“	“	0.01	“	Northampton.
5.	“	“	0.15	“	Northfield.
6.	“	“	0.15	“	Northampton.
7.	“	“	0.01	“	West Springfield.
8.	“	“	0.76	“	Stockbridge.
9.	“	“	0.01	“	Hadley.
10.	“	“	0.06	“	Sheffield.
44.	“	“	1.66	magnesian limestone soil,	New Marlborough.
50.	“	“	0.45	limestone do,	Pittsfield.
51.	“	“	0.76	“	Sheffield.
108.	“	“	0.02	sienite soil,	Gloucester.
109.	“	“	0.01	“	Lexington.
111.	“	“	0.05	“	Newbury.
112.	“	“	0.50	“	Dedham.
120.	“	“	0.05	porphyry soil,	Medford.
122.	“	“	0.05	“	Lynn.
124.	“	“	0.10	greenstone soil,	Woburn.
125.	“	“	0.40	“	Deerfield.

The last column in the general table of results contains the amount of peroxide of iron in the aluminous deposite of the soils. It is less than the quantity in the entire soil: because, although the siliceous part contains less than the aluminous, it is seldom if ever free from this metal. Upon the whole, the soils of Massachusetts contain a rather large per cent of iron.

As to the effect of oxide of iron upon vegetation, agricultural chemists seem in general to have formed no definite opinion: though the idea seems to be rather prevalent that it is generally deleterious. It is well known that iron exists in two states in rocks; that of the protoxide, and the peroxide; the latter containing more oxygen than the former. And Chaptal, the distinguished French chemist, thinks that some of his experiments prove, that the protoxide is decidedly injurious to vegetation. But from the fact that the green sand marl of New Jersey and Virginia, which is operating so favorably upon the lands of those States, contains a large proportion of protoxide of iron, Prof. William B. Rogers suggests whether its fertilizing effects may not proceed in part from the alkaline reaction of the protoxide. I shall soon present some facts and reasonings on this subject by another able chemist, which go to show, that iron, in passing into the state of peroxide, exerts a very favorable effect upon the nutriment in soils: and that when in the state of peroxide, its effect is good as a general fact. In general the iron in our soils is already peroxidized, though not always; and the agricultural character of most of our highly ferruginous soils, as for instance the reddish soils in the Brookfields, in Sturbridge, Brimfield, Wilbraham, Longmeadow, West Springfield, &c. confirms the opinion that iron, although it often gives a meagre aspect to the fields, is yet, in moderate quantities, of great service. This we might presume would be the case, from the fact that it is found in nearly all plants in considerable quantity, and also in every productive soil. As however this opinion will probably be controverted, it may not be irrelevant to say, that Massachusetts affords in many parts, fine opportunities for settling the question; and also for determining in what state and proportion iron is best adapted for agriculture.

New method of analysing Soils.

Without stopping to suggest any means for supplying the deficiencies which the preceding analyses have shown in our soils, I proceed to the developement of a new method of analysis, which I very unexpectedly received from a distinguished chemical friend, and which he has allowed me to present in this Report, with its application to our soils. It is the invention of Dr. Samuel L. Dana of Lowell; to whom, as will appear in the sequel, I am indebted for other important assistance in the way of analysis. In order to its being fully understood and appreciated, a few preliminary statements from myself, in addition to those by Dr. Dana, will be necessary.

Till within a few years past, the state in which vegetable and animal matter exists in the soil, and the changes through which it passes, before being taken up by the roots of the plant, were almost entirely unknown to chemists. Long ago, however, Klaproth had discovered a peculiar substance in the elm tree, which he denominated *ulmin*. More recently it was found by Braconnot in starch, saw-dust, and sugar; and by the distinguished Swedish chemist, Berzelius, in all kinds of barks. Sprengel, and Polydore Boullay have ascertained, also, that it constitutes a leading principle in manures and soils. Hence they called it *Humin;* but Berzelius adopts the name of *Geine*. When wet, it is a gelatinous mass, which, on drying, becomes of a deep brown or almost black color, without taste or smell, and insoluble in water; and, therefore, in this state incapable of being absorbed by the roots of plants. Yet after the action of alkalis upon it, it assumes the character of an acid, and unites with ammonia, potassa, lime, alumina, &c., and forms a class of bodies called *Geates*, most of which are soluble in water, and therefore capable of being taken up by plants. And it is in the state of geates, that this substance for the most part exists in the soil. I have thought it might at least gratify curiosity and perhaps be of some practical use, to add specimens of these forms of geine to the collection of soils. No. 227 is pure geine: No. 226 geate of potassa: No. 225 geate of lime: No. 224 geate of alumina.

It is but justice to say, that Dr. Dana derived his knowledge of geine chiefly from his own researches, made with a view to improve the coloring processes in the Calico Printing Establishment, at Lowell: and his method of analysing soils is altogether original. The statements of Berzelius, indeed, though interesting in a theoretical point of view, afford very little light to the practical agriculturist. Those of Dr. Dana appear to me to be far more important in a scientific as well as practical point of view; although essentially coinciding with those European chemists, so far as they have gone. His method of analysis, derived from his researches, I must say, after having made extensive application of it to our soils, is simple and elegant, and taken in connection with his preliminary remarks, it appears to me to be a most important contribution to agricultural chemistry, and promises much for the advancement of practical agriculture. I trust it will be favorably received by the government, and by all intelligent men, who take an interest in the subject. His preliminary remarks and rules I shall now present in his own language.

" By *geine*," says he, " I mean all the decomposed organic matter of the soil. It results chiefly from vegetable decomposition; animal substances produce a similar compound containing azote. There may be undecomposed vegetable fibre so minutely divided as to pass through the sieve; (see first step in the rules for analysis) but as one object of this operation is to free the soil from vegetable fibre, the portion will be quite inconsiderable. It can effect only the amount of insoluble geine. When so minutely divided, it will probably pass into geine in a season's cultivation. Geine exists in two states: soluble and insoluble: soluble both in water and in alkali, in alcohol and acids. The immediate result of recent decomposition of vegetable fibre is abundantly soluble in water. It is what is called, Solution of Vegetable Extract. Air converts this soluble into *solid* geine, *still partially soluble in water*, wholly soluble in alkali. Insoluble geine is the result of the decomposition of solid geine; but this insoluble geine, by the long continued action of air and moisture, is again so altered as to become soluble. It is speedily converted by the action of lime into soluble geine. Soluble geine acts neither as acid nor alkali. *It is converted into a substance having acid properties by the action of alkali*, and in this state combines with earths, alkalies, and oxides, forming neutral salts, which may be termed *geates*. These all are more soluble in water than solid geine; especially when they are first formed. Their solubility in cold water is as follows: beginning with the easiest, magnesia—lime—manganese—peroxide of iron—(it does not unite with the protoxide of iron) alumina—baryta. The geates of the alkaline earths are decomposed by carbonated alkali. The geates of alumina and of metallic oxides are soluble in caustic or carbonated alkali without decomposition. The geates of the alkaline earths, by the action of the carbonic acid of the air, become *super-geates*, always more soluble than neutral salts. Soluble geine, therefore includes the watery solution—the solid extract caused by the action of air on the solution, and the combinations of this with alkalies, earths, and oxides. Insoluable geine includes all the other forms of this substance."

"Soluble geine is the food of plants. Insoluble geine becomes food by air and moisture. Hence the reason and result of tillage. Hence the reason of employing pearlash to separate soluble and insoluble geine in analysis."

"These are the facts. Will they not lead us to a rational account of the use of lime, clay, ashes and spent ley? Will they not account for the superiority of unfermented over fermented dung in some cases?"

Dr. Dana's remarks in answer to these inquiries I shall omit for the present, and quote the remainder of his remarks preliminary to his rules for analysis. If any sentences seem to be somewhat repetitious of those already quoted, it is sufficient to say, that they were communicated at different times, in private letters, in answer to inquiries which I had made, that I might be sure not to mistake his meaning. On a subject so new, some repetitions are not undesirable.

"Geine forms the basis of all the nourishing part of all vegetable manures. The relations of soils to heat and moisture depend chiefly on geine. It is in fact, under its three states of 'vegetable extract, geine, and carbonaceous mould,' the principle which gives fertility to soils long after the action of common manures has ceased. In these three states it is essentially the same. The experiments of Saussure have long ago proved that air and moisture convert insoluble into soluble geine. Of all the problems to be solved by agricultural chemistry, none is of so great practical importance as the determination of the quantity of soluble and insoluble geine in soils. This is a question of much higher importance than the nature and proportions of the earthy constituents and soluble salts of soils. It lies at the foundation of all successful cultivation. Its importance has been not so much overlooked as undervalued. Hence, on this point the least light has been reflected from the labors of Davy and Chaptal. It needs but a glance at any analysis of soils, published in the books, to see that fertility depends not on the proportion of the earthy ingredients. Among the few facts, best established in chemical agriculture, are these: that a soil, whose earthy part is composed wholly, or chiefly, of one earth; or any soil, with excess of salts, is always barren; and that plants grow equally well in all soils, destitute of *geine*, up to the period of fructification,—failing of geine, the fruit fails, the plants die. Earths, and salts, and geine, constitute, then, all that is essential; and soils will be fertile, in proportion as the last is mixed with the first. The earths are the plates, the salts the seasoning, the geine the food of plants. The salts can be varied but very little in their proportions, without injury. The earths admit of wide variety in their nature and proportions. I would resolve all into '*granitic sand;*' by which I mean the finely divided, almost impalpable mixture of the detritus of granite, gneiss, mica slate, sienite, and argillite; the last, giving by analysis, a compound very similar to the former. When we look at the analysis of vegetables, we find these inorganic principles constant constituents—silica, lime, magnesia, oxide of iron, potash, soda, and sulphuric and phosphoric acids. Hence these will be found constituents of all soils. The phosphats have been overlooked from the known difficulty of detecting phosphoric acid. Phosphate of lime is so easily soluble when combined with mucilage or gelatine, that it is among the first principles of soils exhausted. Doubtless the good effects, the lasting effects, of bone manure, depend more on the phosphat of lime, than on its animal portion. Though the same plants growing in different soils are found to yield variable quantities of the *salts* and earthy compounds; yet I believe, that accurate analysis will show, that similar parts of the same species, at the same age, always contain the inorganic principles above named, when grown in soils arising from the natural decomposition of granite rocks. These inorganic substances will be found not only in constant quantity, but always in definite proportion to the vegetable portion of each plant. The effect of cultivation may depend, therefore, much more on the introduction of *salts* than has been generally supposed. The *salts* introduce new breeds. So long as the salts and earths exist in the soil, so long will they form voltaic batteries with the roots of growing plants; by which, the 'granitic sand' is decomposed and the nascent earths, in this state readily soluble, are taken up by the absorbents of the roots, always a living, never a mechanical operation. Hence so long as the soil is *granitic*, using the term as above defined, so long is it as good as on the day of its deposition; *salts* and *geine* may vary, and must be modified by cultivation. The universal diffusion of granitic diluvium will always afford enough of the earthy ingredients. The fertile character of soils, I presume, will not be found dependent on any particular rock formation on which it reposes. Modified they may be, to a certain extent, by peculiar formations; but all our granitic rocks afford, when decomposed, all those inorganic principles which plants demand. This is so true, that on this point the farmer already knows all that chemistry can teach him. Clay and sand, every one knows: a soil too sandy, too clayey, may be modified by mixture, but the best possible mixture does not give fertility. That depends on salts and geine. If these views are correct, the few properties of geine which I have mentioned, will lead us at once to a simple and accurate mode of analysing soils,—a mode, which determines at once the value of a soil, from its quantity of soluble and insoluble vegetable nutriment,—a mode, requiring no array of apparatus, nor delicate experimental tact,—one, which the country gentleman may apply with very great accuracy; and, with a little modification, perfectly within the reach of any man who can drive a team or hold a plough."

Rules of Analysis.

1. "Sift the soil through a fine sieve. Take the fine part; *bake* it just up to browning paper."

2. "Boil 100 grains of the baked soil, with 50 grains of pearl ashes, saleratus or carbonate of soda, in 4 ounces of water, for half an hour; let it settle; decant the clear; wash the grounds with 4 ounces boiling water; throw all on a weighed filter, previously dried at the same temperature as was the soil, (1); wash till colorless water returns. Mix all these liquors. It is a brown colored solution of all the soluble geine. All sulphats have been converted into carbonates, and with any phosphats, are on the filter. Dry therefore, that, with its contents, at the same heat as before. Weigh —the loss is *soluble geine*."

3. "If you wish to examine the geine; precipitate the alkaline solution with excess of lime-water. The *geate* of lime will rapidly

subside, and if lime-water enough has been added, the nitrous liquor will be colorless. Collect the geate of lime on a filter; wash with a little acetic or very dilute muriatic acid, and you have geine quite pure. Dry and weigh."

4. "Replace on a funnel the filter (2) and its earthy contents; wash with 2 drams muriatic acid, diluted with three times its bulk of cold water. Wash till tasteless. The carbonate and phosphate of lime will be dissolved with a little iron, which has resulted from the decomposition of any salts of iron, beside a little oxide of iron. The alumina will be scarcely touched. We may estimate all as *salts* of lime. Evaporate the muriatic solution to dryness, weigh and dissolve in boiling water. The insoluble will be *phosphat of lime.* Weigh—the loss is the *sulphate of lime;* (I make no allowance here for the difference in atomic weights of the acids, as the result is of no consequence in this analysis.)"

5. "The earthy residuum, if of a greyish white color, contains no insoluble geine—test it by burning a weighed small quantity on a hot shovel—if the odor of burning peat is given off, the presence of insoluble geine is indicated. If so, *calcine* the earthy residuum and its filter—the loss of weight will give the insoluble geine; that part which air and moisture, time and lime, will convert into soluble vegetable food. Any error here will be due to the loss of water in a hydrate, if one be present, but these exist in too small quantities in 'granitic sand,' to affect the result. The actual weight of the residuary mass is 'granitic sand.'

"The clay, mica, quartz, &c. are easily distinguished. If your soil is calcareous, which may be easily tested by acids; then before proceeding to this analysis, boil 100 grains in a pint of water, filter and dry as before, the loss of weight is due to the *sulphate of lime,* even the sulphate of iron may be so considered; for the ultimate result in cultivation is to convert this into sulphate of lime."

"Test the soil with muriatic acid, and having thus removed the lime, proceed as before, to determine the geine and insoluble vegetable matter."*

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* In applying Dr. Dana's rules given in the text, to the soils of Massachusetts, I found it necessary to adopt some method of carrying forward several processes together. I accordingly made ten compartments upon a table, each provided with apparatus for filtering and

As soon as made acquainted with this mode of analysis it appeared to me so much more important and accurate than any other with which I was conversant, that I felt determined, if possible, to apply it to at least a part of the soils of Massachusetts; and by extra efforts, I have the pleasure of presenting in the following table the results of its application to all our soils which I have collected; and I shall show hereafter, similar results with our marls, clays, and other substances, to which this method can be applied.

It is proper to add, that the doctrines of Berzelius and other chemists respecting geine, have been strenuously opposed by M. F. V. Raspail, a French chemist, in his new system of Organic Chemistry, translated by Dr. Henderson, and published in London in 1834. He denies the existence of any such proximate principle in soils as geine, and says, "it will be easy to see that all these phenomena (described by Berzelius and others) apparently so varied, which have given room for the discovery of so many substances analogous in their nature to ulmin, are essentially nothing but a developement of carbon." To prove this position he enters into a long argument. This, however, did not convince Berzelius that he had committed an error; but he was led rather to express a still stronger conviction of the truth of his positions. It is not thought proper in this place to enter into this discussion. But it has occurred to me, that even if Raspail had shown that geine is nothing but carbon, it can hardly be doubted by any one who has made any experiments on the subject, that in all its forms of geine, geic acid, and geates, it is soluble to such an extent as to be capable of being taken up by the roots of plants; and if so it is not of much importance by what name it is called: nor will it affect essentially Dr. Dana's rules of analysis. Raspail, however, asserts that geine is never actually dissolved, but only suspended! Plants, he conceives, are nourished almost entirely by carbonic acid; and in following out his views on this point he is led to the strange conclusion—a legitimate one, however, from his pre-

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precipitations, also 10 numbered flasks, 10 evaporating dishes, and a piece of sheet iron pierced with ten holes, for receiving the same number of crucibles. I provided, also, a sheet iron oven, with a tin bottom large enough to admit 10 filters, arranged in proper order, and a hole in the top to admit a thermometer. The sand bath was also made large enough for receiving the ten flasks. In this manner I was able to conduct ten processes with almost as great facility as one could have been carried forward in the usual way.

mises and no small proof that they are erroneous—that, "possibly, by artificially supplying to the plant, the carbonic acid which is necessary to its growth, the use of any kind of manure may be dispensed with! In fact, if a small plant be reared in pure sand, taking care to water it frequently, it will thrive and flower without difficulty." As to the truth of this statement, here made, this writer will probably find but few chemists at this day who will agree with him. They will doubt whether, in all such cases, the "pure sand" or the water employed has not contained minute quantities of the substances found in the plant, which neither pure water nor pure silica can supply. Or if they admit that the plant might be made to grow till the time of flowering in pure sand; they will deny that it can be made to produce fruit without the presence of geine. At any rate until carbonic acid can be artificially supplied to plants, which even Raspail, would not suppose can ever be done on such a scale as to supersede the necessity of manures, decomposed organic matter must be essential in cultivation; and to ascertain the amount and condition of this, is one great object of Dr. Dana's rules of analysis: nor will their value be the less, because chemists are not entirely agreed as to the nature of the nutritive principle, and because we have some things yet to learn respecting geine.*

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* Some valuable and interesting statements respecting geine, may be found in the "Penny Cyclopedia," Article, *Arable Land*; also in the Edinburgh Quarterly Journal of Agriculture.

Number.	NAME AND LOCALITY OF THE SOIL.	Soluble Geine.	Insoluble Geine.	Salts of Lime.			Granitic Sand.	100 grains heated to 300° F. absorbed in 24 hours.	Absorbing Power in Proportional Numbers.	Specific Gravity.
				Sulphate.	Carbonate.	Phosphate.				
1	Alluvium—Deerfield,	3.5	1.2	2.0		0.9	92.4	3.3	65	2.44
2	do Northampton,	2.8	4.2	2.4		1.0	89.6	2.0	40	2.45
3	do Deerfield,	2.3	1.1	1.6		0.9	94.1	2.1	42	2.58
4	do Northampton,	1.2	2.4	0.9		1.1	94.4	1.2	25	2.68
5	do Northfield,	2.8	2.8	1.5		0.6	92.3	2.9	58	2.55
6	do Northampton,	2.4	0.8	2.8		0.8	93.2	1.4	28	2.55
7	do W. Springfield,	3.2	1.2	1.3		0.7	93.6	3.0	60	2.46
8	do Stockbridge,	3.3	0.8	2.9		0.5	92.5	1.9	38	2.55
9	do Hadley,	2.5	2.3	2.7		1.0	91.5	5.0	100	2.46
10	do Sheffield,	1.3	5.2	1.7		0.5	91.3	3.5	70	2.53
11	do Deerfield,	2.5	2.4	0.8		0.8	93.5	2.0	40	2.58
12	do W. Springfield,	1.5	1.5	1.0		0.5	95.5	1.5	30	2.65
13	Tertiary Argillaceous—Springfield,	4.8	5.8	2.4		1.2	85.8	6.3	126	2.31
14	do Northampton,	4.8	4.6	1.6		0.8	88.2	6.1	122	2.37
15	do Plymouth,	2.9	4.9	1.8		0.9	89.5	4.9	98	2.34
16	do Barnstable,	4.4	5.9	0.9		0.6	88.2	4.9	98	2.39
17	do Sandwich,	2.8	4.9	3.0		1.1	88.2	4.2	84	2.37
18	Tertiary, Sandy—Wareham,	0.5	0.0	0.4		0.4	98.7	0.5	10	2.37
19	do Springfield,	3.2	0.0	1.6		0.6	94.6	1.7	34	2.60
20	Tertiary—Barnstable,	0.0	0.0	0.1		0.3	99.6	0.8	16	2.72
21	do Gloucester,						100.	0.7	14	2.71
22	Sandstone, (Red,)—Deerfield,	0.3	2.6	0.8		0.7	95.6	3.4	68	2.53

23	Sandstone, (Red,)—Longmeadow,	3.2	0.5	3.2		0.6	92.5	3.2	64	2.43
24	do do Wilbraham,	6.1	2.0	1.0		0.8	90.1	2.5	50	2.60
25	do do W. Springfield,	4.1	3.8	4.3		0.7	88.1	2.7	54	2.46
26	do (Gray,)—Granby,	2.7	1.8	0.6		0.8	94.1	3.0	60	2.51
27	Graywacke Soil—Dorchester,	7.6	2.1	1.8		1.0	87.5	4.5	90	2.37
28	do Roxbury,	4.4	3.8	2.3		1.4	88.1	3.9	78	2.43
29	do Brookline,	6.0	5.3	3.1		1.4	84.2	5.8	116	2.34
30	do Walpole,	2.6	5.5	1.9		0.8	89.2	3.1	62	2.31
31	do Dighton,	2.1	3.4	1.9		0.5	92.1	1.5	30	2.34
32	do Middleborough,	1.2	3.7	2.1		0.9	92.1	1.6	32	2.48
33	do Quincy,	2.1	5.0	2.4		1.5	90.0	3.5	70	2.44
34	do W. Bridgewater,	3.4	2.3	1.2		0.6	92.5	2.5	50	2.40
35	do Watertown,	5.6	5.5	1.9		1.1	85.9	4.6	92	2.27
36	do Halifax,	3.3	2.7	0.3		0.8	92.9	1.0	20	2.45
37	do Cambridge,	2.8	3.5	1.8		0.2	91.7	2.6	52	2.45
38	do Taunton,	4.7	2.4	1.8		0.8	90.3	1.8	36	2.44
39	do Attleborough, east part,	2.0	4.1	0.5		0.6	92.8	2.8	56	2.48
40	do do west part,	2.5	6.6	1.9		2.0	87.0	3.7	74	2.21
41	Argillaceous Slate—Lancaster,	5.0	4.5	4.6		0.9	85.0	5.6	112	2.25
42	do Sterling,	6.1	4.6	1.8		0.5	87.0	2.6	52	2.32
43	do Townsend,	6.2	5.0	1.0		1.0	86.8	3.5	70	2.31
44	Limestone, (Magnesian,)—Marlborough,	4.4	2.0	1.4		0.5	91.7	3.0	60	2.43
45	do Lanesborough,	3.0	4.2	1.1		0.8	90.9	3.6	72	2.39
46	do Great Barrington,	3.6	5.0	1.7		0.5	89.2	3.5	70	2.56
47	do Adams,	2.2	3.3	1.5		0.4	92.6	2.8	56	2.46
48	do Williamstown,	3.1	2.0	2.8		0.6	91.5	5.5	110	2.39
49	do Stockbridge,	2.3	5.2	3.9		0.7	87.9	6.0	120	2.45
50	do Pittsfield,	5.4	5.3	1.0		0.7	87.6	3.0	60	2.39
51	do Sheffield,	2.7	4.2	1.8	0.8	0.5	90.0	5.1	102	2.27
52	do W. Stockbridge,	4.0	5.2	1.0	3.2	1.6	85.0	4.5	90	2.39
53	Mica Slate Soil—West Boylston,	6.0	5.1	0.9		0.6	87.4	4.2	84	2.31
54	do do Webster,	5.5	3.1	1.3		1.0	89.1	5.5	110	2.31
55	do do Lunenburg,	5.0	3.4	0.8		1.1	89.7	4.3	86	2.29

Number.	NAME AND LOCALITY OF THE SOIL.	Soluble Geine.	Insoluble Geine.	Salts of Lime.			Granitic Sand.	100 grains heated to 300° F. absorbed in 24 hours.	Absorbing Power in Proportional Numbers.	Specific Gravity.
				Sulphate.	Carbonate.	Phosphate.				
56	Mica Slate Soil—Stockbridge, Mt. . .	3.0	5.5	0.2		1.5	89.8	5.3	106	2.40
57	do do Chester Village, ...	6.0	3.5	1.5		1.5	87.5	4.7	64	2.41
58	do do Bradford, ...	6.5	6.8	2.0		1.2	83.5	6.5	130	2.26
59	do do West Newbury, ...	3.0	5.5	3.5		1.0	87.0	4.8	96	2.37
60	do do Methuen, ...	2.9	2.2	1.5		0.6	92.8	0.9	18	2.53
61	do do Pepperell, ...	3.8	7.0	1.6		0.7	86.9	6.2	124	2.27
62	do do Norwich, ...	4.1	4.3	1.2		0.6	89.8	5.3	106	2.36
63	do do Conway, ...	2.0	4.5	1.7		1.1	90.7	3.2	64	2.53
64	Talcose Slate Soil—Chester, west part, .	1.5	2.1	3.1		1.0	92.3	3.1	62	2.54
65	do do Charlemont, ...	3.8	2.2	1.4		0.6	92.0	3.5	70	2.45
66	Talco-micaceous Slate—Florida, . . .	3.2	8.4	2.4		2.0	84.0	5.8	116	2.35
67	do do Hancock, ...	6.2	5.8	1.5		1.0	85.5	2.3	46	2.31
68	Gneiss Soil—Tewksbury, ...	4.3	3.9	1.2		0.8	89.8	3.5	70	2.41
69	do Stow, ...	4.0	3.0	2.0		1.0	90.0	3.8	76	2.41
70	do Bolton, ...	4.6	3.4	2.1		0.9	89.0	3.8	76	2.40
71	do Uxbridge, ...	2.6	3.0	2.9		0.9	90.6	3.5	62	2.36
72	do Mendon, ...	2.6	2.5	2.4		0.7	91.8	3.4	68	2.51
73	do Tyngsborough, ...	4.5	1.8	0.6		0.6	92.5	2.6	52	2.45
74	do Holden, ...	3.9	4.7	1.4		1.4	88.6	5.0	100	2.37
75	do Dudley, ...	4.0	4.6	1.9		0.7	88.8	5.3	106	2.35
76	do Templeton, ...	5.2	4.1	2.7		0.5	87.5	5.1	102	2.36
77	do Rutland, ...	7.1	5.3	1.0		1.2	84.5	6.5	130	2.27

78	do	Westminster,	5.3	3.8	2.2	3.0	0.7	85.0	4.6	92	2.26
79	do	Royalston,	6.0	3.6	1.9		0.6	87.9	5.4	108	2.27
80	do	Fitchburg,	5.4	3.3	1.0	2.1	0.7	87.5	3.4	68	2.44
81	do	Petersham,	5.7	4.8	2.4		0.4	86.7	4.5	90	2.36
82	do	New Braintree,	6.0	6.3	1.7		0.8	85.2	6.7	134	2.34
83	do	Palmer,	5.7	2.7	2.1		0.6	88.9	2.6	52	2.49
84	do	Enfield,	7.2	4.9	2.5		1.0	84.4	6.4	124	2.29
85	do	New Salem,	3.2	2.7	1.5		0.7	91.9	3.7	74	2.44
86	do	Leverett,	3.3	3.7	2.8		0.7	89.5	4.4	88	2.49
87	do	Hardwick,	6.3	3.3	2.1		0.6	87.7	4.9	98	2.36
88	do	Ware,	5.3	0.7	1.9		0.6	91.5	2.3	46	2.58
89	do	Grafton,	4.5	3.5	2.1		0.6	89.3	5.4	108	2.39
90	do	Brimfield,	5.3	2.1	1.0		0.4	91.2	3.7	74	2.46
91	do	Leicester,	3.9	2.9	2.8		1.3	89.1	5.2	104	2.48
92	do	Otis,	4.7	5.4	1.8		1.1	87.0	6.0	120	2.34
93	do	Becket,	8.3	2.4	2.9		1.1	85.3	6.0	120	2.27
94	do	Buckland,	5.4	2.0	2.1		0.7	89.8	2.8	56	2.51
95	do	Wareham,	2.0	0.6	1.2		0.4	95.8	0.9	18	2.68
96	do	Sturbridge,	5.1	3.7	2.3		0.4	88.5	2.7	54	2.50
97	do	Brimfield, not cultivated,	0.6	3.8	1.1		0.5	94.0	3.7	74	2.60
98	do	West Brookfield, not cultivated,	1.5	5.1	1.6		0.5	91.3	4.7	94	2.68
99	do	Oakham,	4.8	2.2	1.4		0.3	91.3	3.0	60	2.45
100	do	Athol, decomposing Gneiss,	0.3	5.3	2.0		0.3	92.1	3.0	60	2.60
101	Granite Soil	—W. Hampton,	1.2	4.0	1.6		0.8	92.4	2.2	44	2.60
102	do	Concord,	7.1	2.0	1.6		0.5	88.8	2.5	50	2.50
103	do	Duxbury,	4.0	2.0	0.8		0.7	92.5	2.4	48	2.43
104	do	Andover,	5.1	7.5	1.6		0.6	85.2	4.4	88	2.29
105	Sienite Soil	—Lynnfield,	5.1	5.2	1.4		0.6	87.7	4.4	88	2.29
106	do	Marblehead,	5.1	5.0	2.7		0.6	86.6	5.8	116	2.35
107	do	Manchester,	6.5	3.4	0.8		0.6	88.7	4.0	80	2.40
108	do	Gloucester,	2.4	2.2	1.5		0.3	93.6	2.8	56	2.25
109	do	Lexington,	5.4	3.9	2.6		0.6	87.5	6.5	130	2.24
110	do	Danvers,	3.8	6.9	2.7		0.7	85.9	5.0	100	2.34

Number.	NAME AND LOCALITY OF THE SOIL.	Soluble Geine.	Insoluble Geine.	Salts of Lime.			Granitic Sand.	100 grains heated to 300° F. absorbed in 24 hours.	Absorbing Power in Proportional Numbers.	Specific Gravity.
				Sulphate.	Carbonate.	Phosphate.				
111	Sienite Soil—Newbury, ...	5.0	5.5	1.0		0.5	88.0	5.3	106	2.36
112	do Dedham, ...	7.0	4.7	1.0		1.3	86.0	6.2	124	2.24
113	do Wrentham, ...	5.6	5.6	0.8	0.4	1.5	86.1	3.6	72	2.43
114	do N. Bridgewater, ...	2.2	5.9	2.5		0.7	88.7	3.7	74	2.36
115	do Weymouth, ...	2.6	5.1	2.2		0.6	89.5	4.0	80	2.35
116	do Sharon, ...	6.9	8.2	1.7		0.5	87.7	3.2	64	2.32
117	do Marshfield, ...	1.6	2.9	1.1		0.8	93.6	3.7	74	2.45
118	do Abington, ...	2.7	3.7	1.5		0.8	91.3	2.7	54	2.46
119	Porphyry Soil—Kent's Island, Newbury, . .	5.7	4.6	3.3		0.4	86.0	6.3	126	2.26
120	do Medford, ...	8.7	4.2	2.6		0.8	83.7	6.6	132	2.17
121	do Malden, ...	5.2	4.1	3.5		1.6	85.6	6.8	136	2.26
122	do Lynn, ...	4.3	3.5	1.8		0.6	89.8	5.9	118	2.29
123	Greenstone Soil—Ipswich, ...	2.8	9.4	0.7		0.2	86.9	3.6	72	2.22
124	do Woburn, ...	7.7	4.6	1.3		1.2	85.2	6.0	120	2.27
125	do Deerfield, .	3.2	4.3	0.1	2.0	0.3	90.1	2.7	54	2.51

Explanation of the preceding Table of Results with Remarks and Inferences.

The first and second columns need no explanation: and the character of the third and fourth will be fully understood, after reading the remarks of Dr. Dana that precede the Table. They show us the amount of nutriment in the soils of Massachusetts; also how much of it is in a fit state to be absorbed by plants, and how much of it will need further preparation. As this is probably the first attempt that has been made to obtain the amount of geine in any considerable number of soils, we cannot compare the results with those obtained in other places. They will be convenient, however, for comparison with future analysis; and we learn from them, that geine, in both its forms, abounds in the soils of the state, and that it most abounds where most attention has been paid to cultivation. It ought to be recollected, that I took care not to select the richest or the poorest portions of our soils; so that the geine in this table is probably about the average quantity. It is hardly probable that the number of specimens analysed from the different varieties of our soils is sufficiently large to enable us to form a very decided opinion as to their comparative fertility, especially when we recollect how much more thorough is the cultivation in some parts of the state than in others. It may be well, however, to state the average quantity of geine in the different geological varieties of our soils, which is as follows:

		Soluble Geine.	Insoluble Geine.
Alluvium,		2.25	2.15
Tertiary argillaceous soils,		3.94	5.22
Sandstone	do.	3.28	2.14
Graywacke	do.	3.60	4.00
Argillaceous slate	do.	5.77	4.53
Limestone,	do.	3.40	4.04
Mica slate	do.	4.34	4.60
Talcose slate	do.	3.67	4.60
Gneiss	do.	4.30	3.40
Granite	do.	4.05	3.87
Sienite	do.	4.40	4.50
Porphyry	do.	5.97	4.10
Greenstone	do.	4.56	6.10

One fact observable in the above results may throw doubts over the fundamental principles that have been advanced respecting geine; viz., that it constitutes the food of plants, and that they cannot flourish without it. It appears that our best alluvial soils contain less geine, in both its forms, than any other variety, except those very sandy ones that are not noticed in the above results, because their number is so small. Ought we hence to infer that alluvium is a poor soil? I apprehend that we can infer nothing from this fact against alluvial soils, except that they are sooner exhausted than others, without constant supplies of geine. For if a soil contain enough of this substance abundantly to supply a crop that is growing upon it, that crop may be large although there is not enough geine to produce another. Now analysis shows that our alluvial soils contain enough of geine for any one crop: and I apprehend that their chief excellence consists in being of such a degree of fineness that they allow air, moisture, and lime, rapidly to convert vegetable matter into soluble geine, and yield it up readily to the roots of plants: but I presume that without fresh supplies of manure, they would not continue to produce as long as most of the other soils in the state. A considerable part of our alluvia are yearly recruited by a fresh deposite of mud, which almost always contains a quantity of geine and of the salts of lime, in a fine condition for being absorbed by the rootlets of plants. And on other parts of alluvial tracts, our farmers, I believe, are in the habit of expecting but a poor crop unless they manure it yearly. Yet so finely constituted are these soils, that even if exhausted, they are more easily restored than most others; so that taking all things into the account, they are among the most valuable of our soils; and yet I doubt whether they produce as much at one crop as many other soils; though the others perhaps require more labor in cultivation.

The amount of soluble and insoluble geine obtained by Dr. Dana's method of analysis, ought to correspond pretty nearly with the amount of organic matter obtained by the old method; and by comparing the two tables of results that have been given, it will be seen that such is the fact. Several circumstances, however, besides errors of analysis, will prevent a perfect agreement. In the first place, by the old method of analysis, 100 grains of the soil are weighed before expelling the water of absorption; but by the new method, not until after its expulsion. Again, by the old method only the very coarse parts of the soil are separated by the sieve: but a fine sieve is used by the new mode, and this removes nearly all the vegetable fibre, which by the other method is reckoned a part of the organic matter. Other causes of difference might be named: and hence we ought not to expect a perfect agreement in the results of the two methods.

The three next columns in the Table contain the salts of lime in our soils. I have already described the infrequency of the carbonate; but very different is the case with the sulphate and the phosphate which were found in greater or less quantity, in every soil analysed. In respect to the sulphate of lime, or gypsum, it may not be unexpected that we should find it in all soils, since we know it to occur in all natural waters throughout the state; and we cannot conceive of any other source from which the water could have derived it, except the soil. But the phosphate of lime has generally been supposed to be much more limited, nay to be scarcely found in soils, except where animal substances have been used for manure. It is possible that in all the soils which I have analysed, such might have been its origin, though not very probable. Yet there is strong reason to believe, that this salt is a constituent of all soils in their natural state. The arguments on this subject are stated so ably by Dr. Dana that I need only quote from his letter.

"When we consider that the bones of all graminivorous animals contain nearly 50 per cent of phosphate of lime, we might be at liberty to infer the existence of this principle, in the food, and, consequently, in the soil, on which these animals graze. If we look at the actual result of the analysis of beets, carrots, beans, peas, potatoes, asparagus, and cabbage, we find phosphate of lime, magnesia, and potash, varying from 0.04 to 1.00 per cent of the vegetable. Indian corn too, by the analysis of the late Professor Gorham, of Harvard College, contains 1.5 per cent phosphate and sulphate of lime. It may be said that this is all derived from the manure. We shall see by and by. Let us look at the extensive crops often raised, where man has never manured. Rice, wheat, barley, rye, and oats, all contain notable portions of phosphate of lime, not only in the grain but in the straw, and often in the state of superphosphats. The *diseases* too, *ergot* and *smut*, show *free phosphoric acid*. Can it be that, owing to certain electrical influences of the air, in particular seasons, lime is not secreted by the plant to neutralise the free acid ? May not this be a cause of smut and ergot ? Does it not point out a remedy ? Take too the cotton crop of our country. What vast quantities of phosphats do we thus annually draw from the soil ? Cotton gives one per cent ashes, of which 17 per cent is composed of phosphat of lime and magnesia. The like is true of tobacco. It contains 0.16 per cent of phosphat of lime. If we turn to the analysis of forest trees, we find that the *pollen* of the *pinus abies*, wafted about in clouds, is composed of 3 per cent phosphat of lime and potash. May not this too be one of nature's beautiful modes of supplying phosphoric acid to plants and to soils ? If, as the late experiments of Peschier have proved, sulphat of lime, in powder, is decomposed by growing leaves, the lime liberated, and the sulphuric acid combining with the potash in the plant, why may not phosphat of lime, applied by *pollen*, act in the same way ? At any rate, the existence of phosphat of lime in our forest soils is proved not only by its existence in the pollen, but by its actual detection in the ashes of pines and other trees.—100 parts of the ashes of *wood* of *pinus abies* give 3 per cent phos. iron ; 100 parts of the ashes of the *coal* of *pinus sylvestris* give 1.72 phos. lime, 0.25 phos. iron ; 100 parts of ashes of oak coal give 7.1 phos. lime, 3.7 phos. iron ;

100	ashes of	Bass wood	5.4	"	3.2	"
"	"	Birch	7.3	"	1.25	"
"	"	Oak wood	1.8	"		
"	"	Alder coal	3.45	"	9.	"

" These are the calculated results from Berthier's very accurate analyses, and those very curious crystals—detected in some plants—the "*raphides*" of De Candolle, are some of them bibasic phosphats of lime and magnesia. Phosphat of iron, we know, is common in turf ; bog ore, and some barren and acid soils owe their acidity to *free* phosphoric acid. If we allow that our untouched forest soil contains phosphat of lime, it may be said, that this, being in small quantity, will be soon exhausted by cultivation, and that the phosphats, which we now find in cultivated fields, rescued from the forest, s due to our manure ;—I give you the general result of my analysis of *cow dung*, as the best argument in reply. My situation and duties have led me to this analysis. I give you it, in such terms as the farmer may comprehend: water, 83.60; hay, 14.; biliary matter, (bile resin, bile fat and green resin of hay,) 1.275; geine combined with potash, (vegetable extract,) 0.95; albumen, 0.175."

"The hay is little more altered than by chewing. The albumen has disappeared, but its green resin, wax, sulphat and phosphat lime remain, and when we take 100 parts of dung, among its earthy salts we get about 0.23 parts phosphat, 0.12 carbonat, and 0.12 sulphat of lime. Now, a bushel of green dung as evacuated weighs about 87.5 lbs. Of this only 2.40 per cent are soluble. Of this portion only 0.95 can be considered as soluble geine."

Western Soils.

In addition to the preceding arguments respecting the existence of phosphate of lime in the soils, I would state that I found it in every analysis which I have made of the Berkshire marls, the results of which I shall soon present. I have also recently analysed five specimens of soils from Ohio and Illinois, presented to me by H. G. Bowers, Esq., formerly of Northampton, in this state, and now resident in Illinois. They were taken from some of the most productive spots in those states, and, in regard to some of them, it is certain, that no animal or any other manure has ever been applied by man, and at least one of them seems not to have been cultivated, so far as I can judge from its appearance. Yet all these soils contain phosphate of lime. The following are the results of their analysis; which I give, partly because of the subject under consideration, and partly because I thought it might be gratifying to compare the composition of some of the best soils at the west with those in Massachusetts.

	Soluble Geine.	Insoluble Geine.	Sulphate of Lime.	Phosphate of Lime.	Carbonate of Lime.	Granitic Sand.	Water of Absorption.	Remarks.
Rushville, Illinois,	7.4	2.5	3.4	0.6	1.5	84.6	6.3	
Sangamon co., do.	4.9	5.6	1.2	0.4	1.3	86.6	6.3	
Lazelle county, do.	7.6	13.8	1.4	0.4	3.3	73.5	9.5	**Apparently never cultivated.**
Peoria county, do.	3.1	4.8	3.5	1.0		87.6	5.7	
Sciota Valley, Ohio,	4.5	6.7	2.1	0.9	2.8	83.0	5.3	**Cultivated 14 years without manure**

The above soils are evidently of the very first quality: the geine being in large proportion, and the salts quite abundant enough, while there is still a small supply of carbonate of lime to convert more insoluble into soluble geine, whenever occasion demands. Still, if we compare the preceding analyses with some of those that have been given of the Massachusetts soils, the superiority of the western soils will not appear as great as is generally supposed. And there is one consideration resulting from the facts that have been stated respecting geine, that ought to be well considered by those who are anxious to leave the soil of New England that they may find a more fertile spot in the West. Such soils they can undoubtedly find; for geine has been for ages accumulating from the decomposition of vegetation in regions which have not been cultivated: and for many years, perhaps, those regions will produce spontaneously. But almost as certain as any future event can be, continued cultivation will exhaust the geine and the salts, and other generations must resort to the same means for keeping their lands in a fertile condition as are now employed in Massachusetts, viz., to provide for the yearly supply of more geine and more salts.

Importance of the Salts of Lime.

To return from this digression, I apprehend that the importance of the salts of lime in a soil is but little appreciated by farmers in general. Their crops may fail, although they have manured and tended them well; but it is almost always easy to find a cause that satisfies, in the character of the season; but hard to convince them that the failure may have been owing to the deficiency of a single grain in a hundred, of some substance, that can be discovered when present, only by chemical examination. And yet, I doubt not many a crop has failed from the want of that one per cent of sulphate or phosphate of lime. Facts, indeed, seem to me to warrant the conclusion, that, without lime in some form, land will not produce any valuable vegetation.

Granitic Sand.

The eighth column contains the granitic sand in our soils, according to Dr. Dana's definition. Its amount is obtained by subtracting the amount of the geine and salts of lime from 100. No notice is taken in this case of the water of absorption, because the 100 grains operated upon were not weighed out till that water had been driven off.

This granitic sand consists of all the earthy and metallic ingredients of the soil except lime, which has been separated by the process. But concerning the nature and uses of the earthy part of a soil, enough has already been said.

Power of the Soils to absorb Water.

It is generally known, that soils possess the power of absorbing moisture in different degrees. This power depends more upon the geine of soils, than any other principle. Alumina stands next on the list in its degree of absorbing power; next, carbonate of lime; and least of all, silica. Hence there ought to be a general correspondence between the absorbing power of a soil and its fertility; and, therefore, this property affords some assistance in estimating the value of a soil. On this account I was desirous to get the power of absorption possessed by the soils of Massachusetts. 100 grains were heated to 300° F. and then exposed on a small earthen plate for 24 hours, in a cellar, whose temperature remained nearly the same from day to day. The thermometer stood in it at 37° F.; and the *dew point*, by Daniell's Hygrometer, was 33° F. At the end of 24 hours, the soils in the plates were again weighed, and the number of grains which they had gained was put into the ninth column. For the sake of showing at a glance the absorbing power, it is expressed in the tenth column by proportional numbers; 5 grains absorbed, being equal to 100.

I find the winter to be a most unfavorable time for experiments of this sort; and I place but little reliance upon the results which I have obtained. As the experiments were performed, however, with a good deal of care, I thought it best to give them, after stating all the circumstances under which they were made.

Power of Soils to retain Water.

Still more unfavorable is the season of winter for experiments upon the power of soils to retain water; a power which is by no means always proportional to their absorbing power. I did, however, attempt to perform experiments of this sort, by adding 100 grains of water to 200 grains of soil upon broad earthen plates, and exposing them to the sun in a clear day, for three hours. As it was impossible, however, to go through with all the soils in one day in this manner, the results on different days cannot be compared; because evaporation is very different upon different days, even though the air be clear, and the wind westerly, and the temperature nearly the same; which were the circumstances under which the experiments were performed. I will give here, however, some of the results obtained by this process; although I cannot see that they are of much importance. 200 grains of soil, with 100 grains of water, lost, in three hours, as follows:

January 15th.

No. of Soil.		
2	lost	74.5 gr.
45	"	90.6
47	"	68.0
51	"	83.5
54	"	83.4
56	"	90.1
59	"	91.0
87	"	86.6
94	"	94.0
96	"	83.0
122	"	81.5

January 16th.

8	"	81.7
40	"	75.4
41	"	78.4

January 16th.

No. of Soil.		
43	lost	85.8 gr.
44	"	82.5
50	"	92.9
58	"	83.5
60	"	92.7
63	"	69.6
65	"	85.3
67	"	85.8
70	"	88.1
71	"	83.5
77	"	75.7
79	"	80.2
89	"	79.1
90	"	87.4
93	"	77.5
98	"	82.7

January 16th.

No. of Soil.		
101	lost	76.7 gr.
104	“	80.3
106	“	83.6
108	“	85.4

January 23d.

11	“	59.7
12	“	58.2
14	“	64.7
22	“	53.8
28	“	53.9
33	“	52.0
34	“	59.4
39	“	57·8
42	“	55.2
46	“	52.5
48	“	54.5

February 10th.

9	“	55.0
10	“	51.5
13	“	57.0
17	“	69.3
19	“	57.0
29	“	60.0
32	“	55.5
35	“	57.5
37	“	63.0
38	“	55.0
52	“	61.5

February 23d.

No. of Soil.		
55	lost	57.5 gr.
58	“	58.0
61	“	66.5
62	“	63.0
64	“	66.0
66	“	68.0
68	“	65.0
69	“	62.0
73	“	63.5
74	“	65.0
75	“	55.9
76	“	64.9
78	“	57.3
80	“	64.7
81	“	55.0
82	“	64.7
83	“	57.0
84	“	58.9
85	“	54.3
86	“	55.3
88	“	70.1
91	“	74.3
92	“	65.6
95	“	77.3
97	“	64.0
99	“	62.0
100	“	53.0
102	“	66.0
103	“	60.0
105	“	60.0

Specific Gravities.

The weight of the different soils, compared with one another and with water, is given in the last column of the table. As a general fact, it will be seen that the most sandy soils are the heaviest, and those containing the most geine, the lightest. This character, however, is not of very great importance. Pure water is here considered as the standard, or as unity; and the numbers in the table show how much heavier the soils are than water.

General Conclusions.

Without stopping to notice some things of minor importance, I will state at once the most important conclusions that have forced themselves upon my mind, from all my examinations and analyses of our soils, respecting their deficiencies and the means of remedying them.

First, the grand desideratum in our soils is calcareous matter; that is, carbonate of lime.

The second desideratum is an additional quantity of geine; that is, a larger supply of the food of plants.

Hence, thirdly, the great object of the agricultural chemist should be, to discover and bring to light new supplies of both these substances.

The discovery of either of them would, indeed, be of no small value; but it is a principle that ought never to be lost sight of, that an additional quantity of lime in the soil, will commonly require an additional quantity of organic matter, and an increase of the latter, will be far more serviceable, if attended by an increase of the former.

These fundamental principles and conclusions I have kept in view continually; and will now proceed to show with what success I have searched for new sources of lime and of geine. I shall begin with the former as the most important, because the farmer already possesses the means of increasing the quantity of his manure, but not of obtaining calcareous matter; for, with the exception of Berkshire county, Massachusetts is very deficient in limestone.

2. Marls.

No form of calcareous matter is so valuable in agriculture as rich marl. This term, however, has been till recently very loosely applied; often meaning nothing more than loose clay, entirely destitute of lime. But all accurate writers now understand it to mean a friable mixture of lime and clay; although the term is extended to beds of calcareous shells that are somewhat hard. Till within a few years, this substance has been neglected in our country; but its remarkable effects in some of our middle and southern states, have awakened the public attention; and it is now sought after with no small avidity. From the nature of our rocks, I had no hope of finding rich marls in any other part of the state except the County of Berkshire. From that part of the state, many years ago, I had seen a specimen that appeared very rich. I prepared therefore to go in search of the bed from which it was taken; and by the directions of Professor Dewey, I found it in Pittsfield, near the east part of the village, on the borders and in the bottom of a pond covering several acres. It seemed to me very probable that similar beds must occur in other parts of that county where limestone prevails. My search was soon rewarded by the discovery of an extensive bed in the northwest part of Stockbridge on land of Mr. Buck; whose thickness was about two and a half feet, and probable extent, very great. Also a second bed in the same town, only four miles from the courthouse in Lenox. Also a third bed in the north-east part of Lee, at the Mills of Sedgwick and Co., the thickness of which, in some places, is about ten feet; though its extent is but a few acres. Also, several beds in West Stockbridge in various parts of the town. The limited time which I gave to these researches did not allow me to make but slight examinations in other towns. But I have little doubt that similar beds of marl will be found in various other places in the county; especially in Sheffield, Great Barrington, Egremont, Alford, Richmond, Lanesborough, New Ashford, and perhaps in Williamstown, Adams, Cheshire, Dalton, and New Marlborough. I am confirmed in this opinion from the fact that since I visited the county several other beds have been discovered.

A second bed has been found in Pittsfield, about a mile south-east of the village. Also a bed in Stockbridge, a little east of the village. For specimens from both which places, I am indebted to Professor Dewey. A third bed has been found covering several acres in the north-west part of Lee, near a pond, on land of Messrs. Lemuel and Cornelius Bassett. The thickness of the marl, which commences about a foot below the surface, is in some places from four to seven feet, and in others, from ten to twelve feet; and from 200 to 300 loads have been taken from it the present winter by the Messrs. Bassett. Specimens from all the beds that have been described will be found in the collection accompanying this Report. (See Nos. 148, 149, 150, 151, 152, 153, 172, 173, 174, 175.) I am informed also, that a small bed exists in Tyringham, and another in Stockbridge, on the road leading to Lenox.

The purest of these marls when dry, are almost as white as chalk, and much lighter than common soil, as may be seen from the specific gravities of a part of them in the table of their analysis below. When wet they are of a light gray color, especially if they contain much organic and earthy matter: indeed the degree of their whiteness is no bad index of the quantity of lime that they contain. When wet they are quite plastic and adhesive: when dry, they fall into a fine powder. Hence they are in a most favorable state for being spread upon land. They are found almost exclusively in swampy ground, generally in quite wet swamps, and are always covered by a stratum, often several feet thick, of black vegetable matter approaching to peat. Hence, as these swamps are rarely excavated, the marl is not apt to be discovered; or if found, it is supposed to be nothing more than white clay and sand, which, indeed, it does very much resemble. In order to ascertain the presence of marl in a swamp, I prepared an iron rod, several feet long, near the end of which was a groove, in fact it formed a sort of auger. When pressed into the ground and withdrawn, it would always retain in the groove some of the matter from the bottom of the hole, and in this way, in a few minutes, not only the existence of marl might be ascertained, but the thickness of the bed. Yet after all, since the swamps where it occurs are usually very wet, and easily penetrated, a rough pole is better for discovering marl and its thickness, than the iron borer which I have described. For some of it will adhere to a pole plunged into it, even though that pole must be drawn through several feet of vegetable mud above it. And if the pole be plunged to the bottom of the bed, the distance along the pole covered with marl, will show the thickness of the bed; except that the lower extremity of the pole will show beneath the layer of marl the clay or sand as far as they were penetrated; and this extent must be subtracted from the whole length covered with marl. I have been thus particular in describing the method of searching for marls, in the confidence that if gentlemen residing in the towns above mentioned will adopt it, many new beds will be brought to light.

There is a substance in the central and eastern parts of the State, in exactly the same situation as the marl of Berkshire, which resembles it also very precisely in external characters, and is also like marl very light; and yet it is not marl. It does not contain carbonate of lime, but is composed chiefly of silica. Specimens of it will be found in the collection from several places. (See No. 157, which is from Spencer; No. 169, from Barre, and No. 170, from Andover.) It is easy, notwithstanding its general resemblance, to distinguish it from marl by a few drops of vinegar, oil of vitriol, aqua fortis, or any other acid. If it be marl, the acid will produce in it small bubbles occasioned by the escape of gas—if not marl, no effervescence will be produced. And this is a universal test, which is almost infallible, for distinguishing marl in all circumstances.

One other circumstance respecting the Berkshire marl, which will aid in distinguishing it. It abounds every where with small fresh water shells, such as now occur in the ponds of that region, and therefore it is unquestionably true fresh water marl, and not shell marl. The epidermis of the shell is usually gone. Such shells are rarely found in much quantity where lime does not exist, although I have seen them in mud that did not effervesce. But their presence should lead us to search carefully for calcareous matter: for how can these animals form their shells without lime?

The manner in which these Berkshire marls were formed, is very obvious. They result from the carbonate of lime brought into ponds by water, and there at length deposited. After the pond is filled nearly up, vegetables begin to grow over the marl, and thus at length a deposite of peaty matter covers the marl. The process, I doubt not, is now going on in most limestone countries, and thus a vast amount of valuable matter for agriculture is accumulating in spots usually regarded as waste places.

The Berkshire marls, above described, appear to me to be some of the richest and best that ever occur. Marls are usually valued only for the calcareous matter which they contain. But by adopting Dr. Dana's method of analysis, we find that they also contain no small quantity of soluble and insoluble geine, derived from the vegetable matter that covers them. This must make them still more valuable when applied to the soil. They contain likewise a small portion of phosphate of lime, increasing their value still more: while the granitic sand in them, the only part that is of no value, is in most cases extremely small. The following are the results of the analysis of the ten specimens in the Government collection.

No.	LOCALITY.	Soluble Geine.	Insoluble Geine.	Phosphate of Lime.	Carbonate of Lime.	Carbonate of Magnesia.	Granitic Sand.	Water of Absorption.	Specific Gravity.	REMARKS.
148	Stockbridge, (Mr. Buck's farm,) . .	4.3	4.6	0.7	73.4	0.15	13.5	3.3	1.82	2½ feet thick.
151	do south-east of the village, .	5.0	8.9	0.6	46.0	trace.	36.6	2.9		
149	Pittsfield, east of the village, . . .	3.1	3.5	0.7	86.4	0.46	3.1	3.0	1.82	4 feet thick at least.
152	do S. W. of village (Mr. Strong's lot)	3.1	3.2	0.4	64.8	trace.	25.2	1.9		
150	West Stockbridge, (Mr. Reed's land,) .	1.7	5.0	0.5	74.8	0.53	14.7	2.8	1.61	
153	Lee, (Sedgwick & Co's mills,) . .	1.2	2.1	1.0	93.2	no trial	0.9	1.6	1.89	Exposed to the action of running water.
172	do (L. Bassett's bed, near the surface,)	1.8	2.2	1.4	93.0	do	2.2	0.4		9 to 12 feet thick.
173	do do 10 ft. below the surface,	1.6	2.8	1.0	88.8	do	4.4	1.4	1.75	
174	do (C. Bassett's bed,)	2.6	3.4	1.2	86.2	do	5.0	1.6		Nos. 172, 173 and 174 are from the same bed.
175	do (Sedgwick's mills,)	0.8	4.4	1.0	83.6	do	9.2	1.0		Not exposed to the action of runuing water.

The amount of calcareous matter in these marls is unusually large, with the exception of one of the specimens from Pittsfield, and another from the east part of Stockbridge. And since only a small quantity of these was sent to me, which probably might have been taken from the margin of the beds, it is not certain, that my analysis exhibits the average proportion of calcareous matter even in those beds. Again, most marls are only in part pulverulent, or easily crumbled down, and they require a long time after being mixed with the soil, before they will exert a favorable action upon it. But these are all in a state best adapted for immediate use; and when we add to these considerations those already made concerning the other ingredients of these marls, I cannot but feel that Berkshire possesses in them a very great treasure. I doubt not but an inexhaustible supply may be found there, not only for the county but for exportation. And since the most numerous beds yet discovered occur very near the point (West Stockbridge) where two great rail roads are soon to intersect, I cannot doubt that this marl will be among the articles of export, at least a considerable distance. The marls of New Jersey and Virginia, it is well known, are already beginning to be transported a great distance. And if any marls are rich enough to be thus conveyed by land or water, surely those of Berkshire must be of the number. It will doubtless require a long time to satisfy many of our farmers of the value of marl: and especially as we may expect many failures from applying this marl in improper quantity, or in the neglect of collateral circumstances essential to success. But unless a vast amount of experience in the use of marl in Europe and in this country is to be set aside as a ground of judgment, these marls must sooner or later work an important improvement in a portion of the agriculture of this State.

There is an important fact derived from the analysis of soils that have been given, relative to the character of those in Berkshire county. It had formerly been supposed, that the soils of that county contain so much lime, that marls would be of no service there. But it appears that they contain scarcely any more of this substance, either in the form of carbonate, sulphate, or phosphate, than the other soils of the state. At least, the specimens analysed do not; and these were taken at random from fields underlaid by limestone; so that probably they show about the average quantity of lime in the soils of the county; though I doubt not that soils may be found there containing more of this substance. I think this may be a safe rule to follow by the farmers of that county. If a soil effervesces with vinegar, or other acids, they may infer that marl will be of little service. If it do not effervesce, they may safely apply marl. And judged of by this rule, I doubt not that four out of five of the Berkshire soils will be found to need it.

In what Quantity and Mode shall Marl be applied?

I do not conceive that it falls within the sphere of duties assigned me by the government, to go into details respecting the mode and the quantity in which marl shall be applied, except so far as these questions can be answered by agricultural chemistry. It is well known that, in many instances, lands have been injured by over marling; and hence one is met everywhere with the questions above suggested. And certain it is, that no general rules have thus far been followed or proposed. Nor can we get any general rules on the subject until the manner in which lime acts upon soils and vegetation is understood. Here, it must be confessed, great confusion and a variety of opinions have prevailed. The action of lime is undoubtedly quite complex, and considerably different on different soils; which renders any general theory more difficult. The doctrines respecting geine, which have been explained, appear to me to throw more light on this subject than has ever before shone upon it; though some points still remain obscure; and as Dr. Dana has obligingly furnished me with his views on the subject, I shall present them without hazarding any opinion of my own; except to say, that his theory is manifestly in advance of any that has hitherto appeared.

Theory of the action of Lime on Soils, Manure, and Vegetation.

"The action of lime is threefold; each distinct. 1. It is a *Neutralizer:* 2. a *Decomposer:* 3. a *Converter.* 1. I have already alluded to some acid soils: free phosphoric acid, geic, acetic, and malic acids, also occasionally exist in a free state in soils. Here lime acts as a neutralizer. 2. Soils may contain abundant geates; particularly geate of alumina, the least of all demanded by plants. Long formed and sun-baked, they are scarcely acted on by rain or dew, and are almost useless. Here lime, by decomposing these metallic and earthy geates, forms a combination, which, in its nascent state, is readily dissolved. If the carbonate of lime acts better than the hydrate, it is because, following a well known law, double decomposition is easier than single. If any acid geine exists in the soil, or any free acids, carbonic acid is then liberated; it acts on the geate of lime, supergeates result, and these are easily soluble."

"3. The great use of lime is as a *converter;* turning solid and insoluble geine, nay, I go further, solid vegetable fibre, into soluble vegetable food. Here is the great puzzle, the point where our philosophy seems to leave us; giving us our choice, to refer this action to one of the numerous cases of mysterious '*catalytic*' change, with which we are becoming every day more and more familiar, or to explain the process by referring the whole to *saponification*. I use this word as conveying to you at once what I mean;—but I do not mean to say that the product of lime and vegetable matter is soap; but I cannot make myself more intelligible to a farmer than by saying, this lime makes compounds of vegetable matter, just as it makes soapy compounds of oil and fat. The action of lime on geine I take to be of the same nature, as its action on oils and fat. It is well established that animal and vegetable oils and fats are converted into acids by the action of alkalies, earths, oxides, and even by vegetable fibre itself. The general law is, that whenever a substance, capable of uniting with the acid of fat or oil, is placed in contact with fat or oil, it determines the production of acid. Now we have seen that alkali produces a similar change on geine; it developes acid properties. I go further, if alkali has converted vegetable oil and geine into acids, I see no reason why a similar action may not be produced by all those substances which act thus on oil. Hence *lime*, earths, and metallic oxides, convert geine into acid: as fast as this takes place, so fast it becomes soluble. Then too the long action of air on insoluble geine, rendering it soluble, is it not analogous to the action of air on oils. Both evolve in this case, vast volumes of carbonic acid, the oil becomes gelatinous and soluble in alkali; does not a similar change occur in geine? It is possible that during the action of lime on geine, a soluble substance may be produced, bearing the same relation to this process that glycerine does to saponification. These views you will see need to be followed out experimentally. If found tenable, the most signal benefit will result. We place manures on a new foundation, on which great practical results may be erected

Practical application of the Theory of the action of Lime.

Taking the preceding principles as our guide, we may lay down a few general principles for the application of marls.

1. Enough ought to be applied to neutralise all the free acids in a soil; which may be known by its ceasing to produce acid plants, such as sorrel and pine. Generally, however, the amount required for this purpose is small.

2. It will be serviceable to add enough to convert the earthy geates of a soil into geate of lime. The richer a soil is, the greater we may conclude is the quantity of geates which it contains.

3. It will be serviceable to add enough to convert all the insoluble geine and vegetable fibre in a soil into soluble geine. Hence the richer a soil is, and the more manure is added, the more marl will it bear with benefit. Indeed, *there appears to be no danger of adding too much marl, provided a sufficient quantity of manure be also added.* Ignorance of this principle, I apprehend, is the source of most of the failures that have occured in the use of lime upon soils. Farmers have supposed that its action was like that of common manure, viz., to serve as direct nourishment to the plant; whereas it only *cooks the food,* if I may be allowed the expression, which exists in the soil, or is added along with the lime. In nearly all cases of over marling which I have read of, a fresh supply of manure has been found to be the remedy; which shows the truth of the above principle. Agriculturalists have spread marl alone, or with very little manure, upon land that has been worn out, that is, whose geine has been exhausted; and because such soils have not thereby been recruited, they have inferred that lime was injurious. Without acids, or geine, or geates, or vegetable fibre, to act upon, much excess of lime appears to operate injuriously, so as to diminish, instead of increas-

ing the crop. They have also expected a sudden and surprising increase of fertility: whereas in some cases the chief benefit seems to consist in causing the land to produce for a greater number of years, by preventing the ultimate decomposition and escape of the organic matter. In general, however, it will add also to the yearly product: but those who employ marl or lime in any form, ought to moderate their expectations, that they may not be disappointed, and to be satisfied if they can slowly and surely improve their lands as they most assuredly can do, by this substance, provided they do not expect to accomplish it by the use of lime alone.

These general rules can afford only a general guidance as to the quantity of marl proper to be used. Both marls and soils vary so much in their composition, that probably direct experiments will always be necessary to ascertain the quantity of any new variety of marl that will be most serviceable. And should any of the agriculturists of Berkshire county be disposed, as I doubt not they will be, to try the marls above described, I beg leave to recommend to them, as the best practical treatise that has been published in this country, on this subject, "An Essay on Calcareous Manures," by Edward Ruffin, Esq. of Virginia, Shellbanks, 1835. This gentleman has tried a vast number of experiments on the subject, and the perusal of his work is almost indispensable to any one who would successfully prosecute it. He says, "if the nature of the soil, its condition and treatment, and the strength of the marl were all known, it would be easy to direct the amount of a suitable dressing: but without knowing these circumstances, it would be safest to give 250 or 300 bushels to the acre of worn acid soils, and at least twice as much to newly cleared, or well manured land." (Essay pp. 54.) The marl which Mr. Ruffin used was the shell marl; a large part of which has no action on the soil for several years; nor does it contain any geine. On both these accounts probably, the Berkshire marls should be used at first in a smaller quantity; and I suspect that great care will be necessary to avoid using too much.

As to the best mode of applying marl, theory would lead us in general to prefer the method usually adopted, viz: to mix it with compost before spreading it on the soil. And I would here express a hope, that if experiments are made on the Berkshire marls, a portion of the black vegetable matter that lies above them, may sometimes be mixed with them, to see whether it may not become converted into a geate, and thus increase the value of the marl. It would, indeed, be an important discovery, if from the same swamp both the geine and the lime could be obtained, in a state proper to sustain vegetation.

In a few instances the Berkshire marl has been tried upon cultivated land. In the North part of Stockbridge, several years ago, Mr. Hadsel Buck spread 40 loads from the bed on his farm, upon a field of grass, and he describes the effect as excellent. A mile or two east of this spot, Capt. Enos Smith, many years ago, took a quantity from another bed and spread it upon grass ground with very marked benefit. It has also been tried in Pittsfield, by Samuel A. Danforth, Esq. with encouraging success.*

I have supposed that the discovery of earthy substances containing a much less quantity of calcareous matter than the marl that has just been described, might be of great benefit to agriculture in a region so destitute of lime as Massachusetts in general. Accordingly, I have examined our clays and diluvial deposites with reference to this point and shall now give the result of my researches.

3. Marly Clay.

Most of the clays in Massachusetts contain a very small proportion of carbonate of lime, the greater part of which, however, is converted into those curious concretions called claystones, which usually contain more than 50 per cent of carbonate of lime. But it was only in the north part of Berkshire county that I found enough calcareous matter in the clay beds to be of any consequence in agriculture. In other parts of the county, I met with but few clay beds; though I doubt not that others, besides those described below, may be found. The following analysis gives the composition of one specimen from

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* I feel under great obligations to Hon. Judge Walker, and H. W. Bishop, Esq. of Lenox, for their attention and assistance in searching for beds of marl in that vicinity. Also to Charles B. Boynton, Esq. of West Stockbridge. To Sedgwick & Co., and Mr. Lemuel Bassett, I am indebted for the specimens from their marl beds in the government collection. I might name several other gentlemen in that county who have given me much assistance.

North Adams and another from Williamstown, a little southeast from the college. Both were taken from excavations for making brick.

No.	Locality.	Carbonate of Lime.	Silica and Alumina.	Prot-Oxide of Iron.	Carbonate of Magnesia.	Water of Absorption.
146	Williamstown, . .	11.7	68.0	18.0	trace.	2.3
147	North Adams, . .	28.0	43.4	26.9 (?)	0.99	0.7

Can there be a doubt, but clays so rich in calcareous matter as the above, would prove very valuable in cultivation? especially when we recollect that clay alone, destitute of calcareous matter, is of great service to some kinds of land. The bed in Williamstown, from which the specimen analysed was taken, is composed of the common plastic clay; but that in Adams, (a little east of the village,) is unusually sandy; although a part of the same bed, less calcareous, is used for making bricks. On some soils fine sand, so full of calcareous matter, must be excellent. The quantity of magnesia in it is too small to affect its value unless it be favorably. In applying it, the same principles should be our guide as in richer marls. Other beds of marly clay may be found probably, by the use of vinegar or other acids. Nos. 146 and 147 present specimens of the marly clays whose analysis has been given.

4. CALCAREOUS DILUVIUM.

In the red sandstone of the valley of Connecticut river, beds of fetid limestone occasionally occur; and besides, in the towns of Springfield, West Springfield, and South Hadley, the red slaty rock contains a few per cent of carbonate of lime. In early times this rock has been extensively worn away, and the small fragments and fine sand or clay, thence resulting, have been piled up over the greater part of those towns. This accumulation of detrital matter, I call *diluvium*; and on applying acids to it, in very many places in the towns above named, I found it strongly to effervesce, especially when dug from a litle depth. The lime serves as a cement, so that in most places it is almost as hard as a rock, and requires a good deal of labor to get it up. But exposed to wet, heat, and cold, it at length crumbles down, and becomes fit to spread upon land; although the size of the pebbles often might injure grass fields, unless it were separated by means of a riddle. Since this diluvium was deposited, a thick layer, first of clay, and above this, of sand, has been brought over most of the region, so that the diluvium appears only in those places where the sand and clay have been worn away. But this occurs so often that it is accessible in a multitude of places. I will mention the banks of Agawam river, a little west, and also south, of the village of West Springfield; also at the south end of the village of Springfield, in several places along the banks of the small river on which stand the lower "Water Shops." In one spot on the north bank, is an elevation belonging to the United States' Government, which ten years ago was nothing but a barren sand hill. A large quantity of this diluvium, and of the disintegrating slaty rock beneath it, was carted upon this spot, and not only has it fixed the sand, but produced a coating of clover, grass, and young locust bushes. I was there informed, that near the same spot, six or eight years ago, some of this diluvium was put upon a small sandy ploughed field, and that the good effects are still visible. In another case eight years ago, some of it was mixed with a small quantity of hog manure, and the land still produces better crops. The testimony here, and also at Chicopee Factory Village, as well as in West Springfield, was, that wherever this diluvium is spread, clover soon makes its appearance; a result almost uniformly attending the judicious application of marl.

In the banks of Chicopee river, in numerous places from its mouth nearly to Putts Bridge, thick deposites of this diluvium appear. An enormous bed of it exists on the east bank of Connecticut river, a little south of the village at South Hadley Canal. It occurs, also, in abundance, a little south of the village of South Hadley. I have searched in vain for it in other parts of the valley of the Connecticut. No where else in Massachusetts does the red sandstone appear to contain enough of carbonate of lime to make its detritus sensibly calcareous. And although I have been told, on good authority, that in the vicinity of Hartford and Middletown, Ct., the diluvium does effervesce with acids, yet after repeated trials in various places from Massachusetts to Middletown, I have not found any that was sensibly calcareous. At present, therefore, I must consider this variety confined to the three towns above named; though I doubt not that I might safely add Longmeadow and Wilbraham. I have analysed only three specimens; but these probably will give us about the average amount of carbonate of lime. The specimens analysed will be found in the state collection.

No.	Carbonate of Lime.	Silica and Alumina.	Carbonate of Magnesia.	Peroxide of Iron.	Water of Absorption.	Locality.
154	6.3	80.0	slight precip.	12.4	2.3	Chicopee Factory, Springfield.
155	4.8	83.2	slight precip.	11.0	1.0	Springfield, Lower Water Shops.
156	8.0	71.6	0.4	19.0	1.0	West Springfield.

The amount of calcareous matter in this diluvium appears small, when compared with that in the Berkshire marls. And I presume it will not be found valuable enough as a manure to be transported a great distance. But it ought to be recollected, that it needs only a small quantity of lime in a soil to work wonders upon vegetation. And further, it happens that in the immediate vicinity of nearly every bed of this substance, is a great deal of that sterile sandy land, which most needs a coating of marly clay, which is in fact the character of the calcareous diluvium. The large quantity of peroxide of iron which it contains, will probably also be useful on such a soil. And where this substance can be carted directly upon such fields, I cannot doubt, but they might be made permanently fertile without great expense. I trust that some of the farmers in the vicinity of this diluvium, will at least be tempted to try a few square rods of sandy land in this manner; and then they can judge whether its more extensive application may not be profitable. Who knows, but this substance, which has hitherto been regarded as a sign of utter barrenness, and employed only for mending roads, may at some future day spread fertility over many a field now scarcely worth cultivation!

I ought to remark, that in many places, beds of this diluvium occur which contain little or no calcareous matter, because the rocks from which they were derived, contain none. Hence in using this substance upon soils, none ought to be employed which does not effervesce with vinegar, or other acids. By omitting this precaution, an experiment may fail, which would otherwise succeed.

5. Limestones in Massachusetts.

Such is the general deficiency of calcareous matter in Massachusetts, and so important is it in a variety of arts besides agriculture, that it seems desirable to ascertain the exact value of all the varieties of carbonate of lime within our limits. Besides the rich and pure limestones of Berkshire County, we have a large number of beds of this substance more or less pure, in various parts of the state; and I have thought it desirable to analyse specimens from every bed of consequence. The following table exhibits the results which I have obtained. Some of the specimens were formerly placed in the state collection; and those discovered since that collection was made up, are forwarded herewith.

NUMBER.	LOCALITY.	Sp. Gravity.	Carbonate of Lime.	Carbonate of Magnesia.	Carbonate of Iron.	Silica and Alumina.	Per cent of Quicklime.
429 of State Collection,	**North Adams—Crystalline, white,**	2.74	99.6		trace	0.4	55.78
432 do	Lanesborough—White Marble,	2.69	99.4		trace	0.6	55.66
437 do	do Grey Marble,	2.76	93.2	5.5	0.88	0.3	52.26
433 do	**New Ashford—Flexible White Marble,**	2.68	81.5	16.2	0.88	1.4	45.65
436 do	**Sheffield—Granular Dolomite,**	2.84	58.4	40.4		1.2	32.70
485 do	Bolton—Crystalline,	2.80	61.8	27.0		1.2	34.61
491 do	Chelmsford—Crystalline,	2.85	56.28	39.2	1.32	3.2	31.52
470 do	Bernardston—Crystalline,	2.72	98.1		0.90	1.0	54.94
211 do	W. Springfield—Fetid, Paine's Quarry,	2.73	93.48	0.9		5.6	52.35
459 do	Whately—Grey, Micaceous,	2.72	66.0			34.0	36.97
463 do	South Hampton—Micaceous, Grey,	2.93	38.4			61.6	21.50
496 do	Stoneham—White Compact,	2.84	58.84	15.6	1.76	23.8	32.95
494 do	Walpole—Grey, Granular,	2.80	70.3			29.7	39.37
184 New Specimen,	Attleborough—Compact Grey,	2.71	94.6			5.4	52.98
185 do	Springfield—Chicopee, Compact Ferruginous,	2.74	44.8	26.6	8.2	20.4	25.08
188 do	Norwich—Micaceous, Grey,	2.79	53.8			46.2	30.13
191 do	Springfield—Chicopee, Fetid, Grey,	2.73	86.8			13.2	48.61
192 do	Sheffield—White Crystalline,—Girard College Quarry,	2.75	97.8			2.2	54.77
195 do	Egremont—White Marble,	2.69	92.8	1.2		6.0	51.97
202 do	West Natick—Grey Crystalline,	2.75	72.1	7.5		20.4	40.38
206 do	do Compact, Yellowish,	2.68	54.2	0.6		45.2	30.35
203 do	Claystone—Hadley,		56.6			43.4	31.70
204 do	do North Adams,	2.60	53.6	1.2		45.2	30.02
205 do	do West Springfield,	2.68	48.4			51.6	27.10

New localities of Limestone.

The localities of the limestones in the preceding table, of which specimens have been heretofore deposited in the State collection, will need no further description. But several of the specimens were obtained from new localities, and these will require a few descriptive remarks.

One is marked from Attleborough. I found a bed of it several inches, and perhaps several feet (for it is partly concealed) in thickness, on land of Thomas Arnold, in the southwest part of the town, near what is called the City. The rock there, is a remarkable variety of blood red greywacke conglomerate; and in the stone walls I noticed frequently a mixture of limestone. Hence I anticipate that probably beds of limestone thick enough to be worked may be discovered. It will be seen from the above table, that it is a quite pure carbonate of lime; and being often intermixed with the red slate, it would form when polished, a beautiful marble, if masses large enough can be obtained.

Two specimens given in the table are from the bed of the Chicopee River, at the Chicopee Factory Village, in Springfield. The first (No. 185) occurs abundantly all along that river in nodules, from half an inch to a foot in diameter, which, when broken, often show numerous seams filled with calcareous spar, and constituting what in Europe is called *Septaria*. This limestone also exists along that river, and especially in the bed and banks of Agawam river, in West Springfield, in layers several inches thick; which having the general reddish appearance of the rock, is not suspected to be limestone. Yet if I mistake not, this limestone will prove a very valuable material for preparing the Roman or water-proof cement. I strongly suspect that the fetid limestone of West Springfield, which is now used, is much less adapted for this purpose than the ferruginous limestone under consideration; and the chemical analysis of the two varieties confirms me in this opinion. For the former is almost a pure limestone, whereas the latter abounds in alumina and iron; which are very important in this kind of mortar: and it is well known, that the septaria of Europe is employed for this purpose.

The specimen of fetid limestone (No. 191) from Chicopee Factory Village, scarcely differs from that used in West Springfield, at Paine's quarry. It abounds in the bed of the stream at Chicopee Factory: though in general it is not so highly charged with lime as the specimen analysed. I doubt not but it would answer well in agriculture, if it be not needed for water proof cement.

The specimen No. 188, was sent me from the east part of Norwich, where it is said to abound. It is a variety of the micaceous limestone, so common on the west side of Connecticut River in a large number of towns. The analysis shows a rather too small proportion of carbonate of lime to render it very profitable to burn for common mortar unless the price of wood be quite low. It contains, however, rather more than 50 per cent of carbonate of lime, and in England it is a rule that limestone may be advantageously burnt that contains more than half of calcareous matter. As I have not visited the locality, I cannot say whether richer specimens may not be found there.

The specimen from Southampton (No. 463 of the State collection,) is of the same description, but containing still less of lime; too little, indeed, to be burnt for mortar. That from Whately (No. 459 of the State collection) is the best of this sort of limestone that I have found in any place; and situated very favorably for burning and transportation. Indeed, since my former report was finished a company have erected a lime kiln there, which has been several times filled and burnt with as encouraging success as could be expected in a new enterprise. They undertook it chiefly for agricultural purposes but the lime is found to answer tolerably well for laying brick and plastering. It requires, of course, less sand than purer limestone; and does not harden so soon as some kinds of lime; but at length it becomes unusually solid. When the value of this limestone shall be more fully appreciated, I predict that it will come into use, not merely in Whately, but also in many other towns where it occurs; as in Conway, Ashfield, Buckland, Charlemont, Heath, Colraine, Leyden, Williamsburgh, Goshen, &c. Indeed, I learn that a kiln of it has been burnt in Buckland and used on land with good success.

Berkshire Limestones.

It is gratifying to find, that as the demand for the rich and enduring marbles of Berkshire increases, new and extensive quarries are opened; which prove that it is doubtful even yet, whether others still better than any now wrought, may not yet be discovered. Indeed, when passing over that limestone region, and noticing the quarries, I have often been unable to see, except in the necessity of beginning somewhere, why a particular spot was selected for the excavation, in preference to a dozen others equally promising. In North Adams, on Hudson Brook, a little north of the village, and near the remarkable gorge and natural bridge, a quarry has been recently opened, which furnishes the most highly chrystalline and the purest limestone in the State. By the analysis above given, it appears that it contains less than one per cent of foreign matter. It will of course form a very white and enduring marble : though its highly chrystalline character, may detract somewhat from its elegance. The quarry is inexhaustible.

Another new quarry I noticed two and a half miles west of the village of Pittsfield. This also is inexhaustible, and though the rock is not as white as in some other places, it produces a substantial and valuable marble.

But a visit to the quarry in Sheffield, two miles north of the village, from which marble is now being got out for the Girard College in Philadelphia, will give one perhaps the best idea of the value and extent of the Berkshire marbles; and at the same time of the power which the arts give to man over nature. The rock (No. 192) is no better than in many other places; perhaps inferior to some other varieties—but to see masses more than 50 feet long, and 6 or 8 feet thick, split out by the apparently feeble means employed, makes a strong impression on the mind, and recalls the history of the enormous blocks of stone quarried and removed by the pyramid builders of antiquity.

The celebrated quarries in West Stockbridge still continue to be wrought and in increased quantity. And when the two rail-roads that will here intersect, and connect this point with Boston harbor and

Long Island Sound, shall be completed, we may expect that the demand for this marble, as well as for that from other parts of Berkshire, will increase. These marbles have long been justly considered as among the best for elegance and durability which our country produces; and I have no fears that their high character will suffer by being more extensively known and tested.

There is, however, a considerable difference among these marbles in their durability and power of resisting change from the action of the air, heat, cold and moisture. And it would be very desirable to be able from inspection, to decide which are the best in this respect. I had hoped in this report, to make some remarks on this subject: but do not feel yet prepared. I cannot but fear, however, that no tests which chemistry affords, will ever supersede the necessity of actual trial. It often happens, however, that where a new quarry is opened, fragments of the rock lie scattered on the surface, which have for a long time been exposed to atmospheric agencies: and from the greater or less disintegration which these have suffered, some conjecture can be formed respecting the rock proposed to be quarried.*

Magnesian Limestone in Agriculture.

Very many limestones contain magnesia, and it seems to be generally admitted, that where this is the case, a large quantity spread upon soil is injurious; that is, when the stone has been burnt so as to drive off the carbonic acid. In small quantities, however, it would seem that even calcined magnesia is useful; as we might presume it would be from the fact that most soils contain it in small quantity. Again, it appears probable, that magnesian limestone, if not burnt, but merely reduced to a fine powder, will operate favorably: or even if we admit that in such a case the magnesia exerts no action, it will not prevent the salutary action of the lime united with it. But since magnesia unites with geic acid and forms a compound more soluble in water than geate of lime, there is reason to believe that magnesia, properly applied, may be of service in agriculture. It would be very desirable that some experiments should be made upon this subject: for it will be seen by the analysis of our limestones that has been given, that many of them are magnesian. In the southern part of Berkshire county, the real dolomite, which contains 40 per cent of magnesia, is common; and it occurs in smaller quantity in many of the limestones of that county. Nor is it easy by the eye to determine whether a limestone be magnesian. The dolomite, however, is very liable to disintegration, and hence it is easily reduced to powder; and from the principles above suggested, I infer that this is the proper way to prepare magnesian limestone for agricultural purposes. Indeed, I would extend the remark to all limestones where fuel is not abundant. For the great object of burning lime, so far as its application to soils is concerned, is to reduce it to powder. Indeed, when applied in the state of quicklime it is very apt to prove injurious, like magnesia, until it has absorbed carbonic acid from the atmosphere: that is, until it is brought back to the state in which it was before burning. The inhabitants of Berkshire county will probably never need to use magnesian limestone for agriculture, or any other purpose, because they have enough that is free from magnesia. But much of their dolomite might be more easily reduced to powder than any limestone could be burnt. And if this suggestion about pounding and grinding limestone be of no importance in respect to that which contains magnesia, it may be of consequence in regard to that great quantity of fragments of pure white limestone, which are necessarily accumulated at the quarries, and which are now entirely wasted. How little additional labor would it require, by means of water power, to bring these into the state of powder admirably fitted for agriculture! and who can doubt, but this might become an article of exportation, when the contemplated rail-roads are completed, and the value of lime upon land shall be as much appreciated in this country as it is in Europe!

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* Through the liberality of several gentlemen who have the direction of the marble quarries in Berkshire, and the obliging intervention of H. W. Bishop, Esq., I have the promise of specimens of all the important varieties of marble in the county. As soon as they are received, they will be deposited in the State Collection, with the names of the donors: and those gentlemen who wish to procure marbles, can make their selection, without the trouble of a journey to Berkshire.

Limestones in the Eastern part of the State.

These remarks will apply with still greater force to the limestones in the eastern part of the State, than to those of Berkshire: first, because fuel is much more scarce in the vicinity of the sea-board, and secondly, because, as appears from the analysis that has been given, most of the limestones in that region contain magnesia, in such quantity that it would be desirable to have them pulverised rather than burnt for agriculture. The amount of magnesia in these limestones, is, indeed, greater than we could have anticipated, especially at Bolton and Chelmsford; and I regret that I have not time to repeat their analysis. Still from the fact that these limestones have been powerfully acted upon by heat from the surrounding unstratified rocks, we should expect magnesia in them. These limestones also, from having been melted, and containing more siliceous matter, will be more difficult to be brought into the state of powder by mechanical agency. Yet since, on account of the high price of fuel, but little lime is burnt at these quarries, it certainly deserves consideration whether water power may not be profitably applied to bring them into a state of powder, by some of the machines that are described in agricultural works for this purpose.

The locality from which the two specimens given in the preceding table as from Natick, I have not visited: since it was only a few weeks ago that I was made acquainted with the existence of limestone there. It was brought to my knowledge by Chester Adams, Esq., who says that the bed from which No. 202 was taken, lies three quarters of a mile N. E. of the Worcester and Boston Railroad Depot, and was opened and some of it burned, during the revolutionary war, but was subsequently abandoned; not on account of its quality, but from the high price of fuel, and the low price of lime in the market. He says, also, that one gentleman has ground it for manure. The other specimen (No. 206) of a yellowish color and compact, was blasted from the rail-road, not far from the locality above named, where it was found in considerable quantity. The analysis shows that this variety contains a larger proportion of siliceous and aluminous matter. I am indebted for the specimens in the collection to Mr. Daniel Adams, Jr., of Amherst college.

The three last specimens whose analysis is given in the table (Nos. 203, 204, 205) are those singular concretions occurring in our beds of clay and usually called *claystones*. Probably they will never be of much benefit to the agriculturist, because it is doubtful whether they occur any where in sufficient quantity to be employed upon land. In a scientific point of view, however, they possess a good deal of interest, and if abundant enough any where, they may be used as limestone; for it appears that they all contain more than 50 per cent of carbonate of lime.

A good many other varieties of limestone might have been analysed from Berkshire: but I have intended to select the most important. In other parts of the State I know of a few limited beds, which are of so little consequence, that I have neglected them.* And from what I have given, I think the Government will be able to form a fair estimate of the extent and value of this most important article in the State. Had the vast beds of it in Berkshire county been spread over the whole State, or could they, by any mode of conveyance, be thus diffused, the supply for every purpose of architecture, mortar, and agriculture, would be abundant. And I doubt not but ere long this will happen to some extent. But without some such means, the supply in other parts of the State is scanty. I have, therefore, searched anxiously for other substances, that might answer, at least to a good degree, as a substitute for lime in agriculture. I have met with some success: and I have a hope that, if experiments should be tried upon some substances which I shall now proceed to point out, they will be found of importance.

6. Green Sand.

This substance constitutes a large part of what in New Jersey goes by the name of marl; and which, within a few years past, has wrought such wonders in some parts of that State. It is found also in Virginia, and probably may be found in all the southern States, that extend to the Atlantic. In my former report I described this substance as forming a bed of considerable thickness at Gay Head, forming a part of the tertiary formation there. I also intimated in the same place, that probably it existed on the continent at Duxbury. This point I determined if possible to settle during the last summer, and proceeded to Duxbury accordingly. And in the extreme north-westerly part of the town, or rather for the most part within the bounds of Marshfield, about two miles southwest from the seat of Hon. Daniel Webster, I found the spot described by Rev. Mr. Kent, as given in my former report. I was surprised to find the region abound in low hills of granite, with occasionally a swamp or small stream, being in fact, as unpromising a spot for green sand as I had seen in the State. Yet here I found that the green sand had been thrown up from at least three wells; one of which (on widow Sprague's place,) is in Duxbury, and the other two in Marshfield, near a small stream called South River. In the well on Mr. Kent's farm, (that described in my former report as in Duxbury,) the green sand was struck at the depth of 13 feet from the surface. In the other, that on the farm of John Chandler, Jr., it was struck at the depth of 21 feet; and the bed was five feet thick. This spot was nearly 20 feet above South River; and it occurred to me that perhaps on the margin of the stream the sand might be found, just beneath the surface. I caused an excavation to be made there, and after passing through one foot and a half of black mud, and the same distance through yellow sand and gravel very much consolidated, I had the pleasure of reaching the green sand. This spot is perhaps 15 or 20 feet above tide water. An extensive swamp extends from this place through the west part of Duxbury several miles, and I have reason to suppose the green sand may be found along its whole extent. Indeed, I strongly suspect that it may be found abundantly along the coast from Marshfield to Plymouth, and not improbably also on Cape Cod. The general aspect of a large part of Plymouth and Barnstable counties is very much like the region where this substance occurs.

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* I did not happen to have any specimen from the numerous limestone beds in Newbury.

The coloring matter of this sand forms but a small proportion of the whole mass wherever it has yet been found; yet it imparts a decided green tinge to the whole. The specimens which I obtained at Marshfield, however, contained probably much less than the average quantity of the green matter. For some of it had been exposed to the action of rain, &c, for several years; having been formerly thrown out of a well; and that from the excavation which I made, was obtained only a few inches below the upper part of the bed. The specimen in the state collection, (No. 158,) bears a stronger resemblance to the green sand found on the continent of Europe, than to that from New Jersey. It became a point of much importance to identify this with other green sands. This could be done only by chemistry: and I am happy to be able to present here the very accurate results of analysis, which Dr. S. L. Dana, at my request has obtained, whereby the identity of this green sand with those of Europe, is completely established.

"The *green sand* from Marshfield," says he, "was treated as follows to separate the green particles. Washed in a large volume of water, the black, brown, and green particles subside, mixed with many quartzy grains. The grains form about one half the whole bulk. These grains were then washed in a smaller quantity of water, and the attrition caused the water, at each successive washing, to become ochrey, and I began to think that I should wash nearly all away.* I then treated the grains with dilute muriatic acid—washed them anew, dried and passed them through a sieve. The whole looked like mustard seed, with a few light green particles here and there among the black, green, and brown particles of quartzy grains. Pulverised, the whole becomes ochre brown. It was dried at 212°, and the analysis conducted as usual, gave—

Water	6.50
Black oxide Iron (ferroso-ferrique of Berzelius,)	64.944
Alumina	4.372
Silex	23.0
Lime	0.536
Magnesia	0.648
	100.

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* The specimen which I sent Dr. Dana, had probably lain upon the surface of the ground for several years, and the iron had most likely become somewhat peroxidized."

"The earths, if silicates, will require 4.721 silex; and on no supposition will the remaining silex and water convert the iron into a hydrated silicate. Hence the iron is not combined with the silex, but exists as a hydrated oxide of iron. The composition will then be; free silex, 18.289; hydrated oxides of iron, 71.444; silicates of $\frac{\text{alumina, } 4.372}{\text{silex, } 3.886}$ + of $\frac{\text{lime, } .535}{\text{silex, } .316}$ + $\frac{\text{magnesia, } .648}{\text{silex, } .519} = 10.277$. If we allow the hydrated iron to be mixed, a portion with the above silicates, except the lime, which Berthier and Turner did not find essential in their analyses of the coloring matter of green sand, we have a small portion of this coloring matter mixed with a large portion of hydrated oxide of iron. Only about 5 per cent of the whole is green sand, similar in its composition to that examined by the late Professor Turner, as stated in Dr. Fitton's "Remarks on the Strata below the chalk, &c., in the south east of England;" p. 108.

In a subsequent letter, Dr. Dana gives the result of his analysis of the green sand from Gay Head, of which No. 72 in the state collection, in the rooms of the Boston Natural History Society, is an example. This gives a better idea of the ordinary appearance of this substance than the specimen from Marshfield.

"I have finished the Vineyard green sand. It is very near the results of Turner. I washed the whole in water, poured off the light part, washed the remainder repeatedly, reserving the washing, which let fall a fine powder of a decided green tinge, feeling, when dry, under the pestle, like soapstone powder. The residuary quartzy grains were rejected, a few fine green particles among them. The second portion alone, was taken as the best sample of coloring matter, and gave—

Water	7.000
Silica	56.700
Alumina	13.320
Oxide of Iron	20.100
Lime	1.624
Magnesia	1.176
Manganese, traces, and loss	0.080
	100.

"The water and iron are nearly the same, the alumina the mean, and the silica about 6 per cent more, than the analysis of Turner and Berthier. No doubt therefore it is a true green sand."

The above analyses do not give the actual per cent of this green substance in the soil where it is found, though it evidently cannot form a large proportion. But this is not necessary in order that very decidedly good effects should result from its use in agriculture. The following extract from the report of Professor Henry D. Rogers, on the Geology of New Jersey, bears on this point as well as upon the general value of green sand in the cultivation of the soil.

"When we behold," says he, "a luxuriant harvest gathered from fields where the soil originally was nothing but sand, and find it all due to the use of a mineral sparsely disseminated in the sandy beach of the ocean, we must look with exulting admiration upon the benefits upon vegetation, conferred by a few scattered granules of this unique and peculiar substance. The small amount of green sand dispersed through the common sand, is able, as we behold, to effect immeasurable benefits in spite of a great predominance of the other material which we are taught to regard as by itself so generally prejudicial to fertility. This ought to exhibit an encouraging picture to those districts not directly within the limits of the marl tract, where some of the strata possess the green substance in sensible proportion. It expands most materially the limits of the territory where marling may be introduced and points to many beds as fertilizing, which otherwise would be deemed wholly inefficacious."

In another place of his most valuable Report, Prof. Rogers says, that "Mr. Woolley manured a piece of land in the proportion of two hundred loads of good stable manure to the acre, applying upon an adjacent tract of the same soil his marl in the ratio of about twenty loads per acre. The crops, which were timothy and clover, were much the heaviest upon the section which had received the marl, and there was this additional fact greatly in favor of the fossil manure over the putrescent one, that the soil enriched by it was also entirely *free of weeds*, while the stable manure had rendered its own crop very foul." Placing the home value of the farm yard manure at one hundred cents for each two horse load, and that of the marl at twenty-five cents per load, we have the expense of manuring one acre 200 dollars, of marling the same 5 dollars." "Land which had been sold at 2½ dollars per acre, in consequence of the permanent increase in its fertility from the marl, is now worth 37 dollars the acre."

There is one fact, however, that will throw a doubt over the probable utility of this substance in Massachusetts. By taking the average of eight very accurate analyses of the New Jersey green sand, as given by Prof. Rogers, we find that it contains 10 per cent of potassa. Mr. Seybert's analysis gave nearly the same amount, and Mr. A. A. Hayes informs me that in two varieties analysed by himself, he found 7 per cent of dry oxide of potassium. But only a trace of potassa was found by Dr. Dana in the Massachusetts green sand, which, in this respect, compares with the English green sand analysed by Prof. Turner. Now Prof. H. D. Rogers imputes the value of this substance in agriculture almost exclusively to the potassa which it contains; and no chemist will doubt but that this ingredient will exert a very salutary influence upon soil. Yet there are other ingredients in the green sand, which some will suppose may increase its fertilizing power. One of these is the protoxide of iron, whose quantity is large, and which Prof. William B. Rogers, of Virginia, supposes may be of service, by its alkaline character, upon vegetation. This view will receive confirmation by some facts and reasonings that will be presented when I come shortly to speak of the application of clay in agriculture. It is probable, also, that the lime and magnesia in the Massachusetts green sand, may aid in a similar way. That all the good effects of this substance upon soil in New Jersey cannot be imputed to the potassa, seems probable, from the fact that granite and gneiss contain quite as large a proportion of potassa, and when spread in a powdered or decomposing state upon the soil, ought, therefore, to fertilize as much as the green sand; especially as Mr. Hayes informs me that the New Jersey green sand "decomposes in nitric acid slowly, being less soluble than some feldspars." But there is no evidence that the good effects of the granite and gneiss are as great as those of the green sand; and hence we must call in the aid of some other ingredient to explain its fertilizing power.

I do not, therefore, despair of our green sand in agriculture. It certainly deserves a fair trial, when we consider what a change this substance is producing in much of the poorest land in New Jersey and Virginia. It would be very easy to obtain an abundance of it at Gay Head, where it occurs in great quantities, towards the north end of the cliff. Or I doubt not but it may be found in many places along the coast in Barnstable and Plymouth counties, a few feet beneath the surface, in the lowest places. Very likely a little research may bring to light varieties that contain potassa; and should this be the case, the change that might thereby be produced in the agriculture of the south-east part of Massachusetts, can hardly be calculated.

7. Clay in Agriculture.

There is abundant evidence that our common clays are of great value when spread upon land. I find that they have been used to a considerable extent in the state; so commonly, indeed, that I abandoned the idea I had formed of giving a detailed account of particular instances. So far as my inquiries have extended, the testimony is decided that our blue clays exert a very favorable effect upon the soil. When spread upon sandy ground we might expect that they would render it a better resevoir for salts and geine. But thoroughly to ameliorate our sandy soils in this way, requires far more clay than is usually employed, and I am perfectly convinced that they exert other than a mechanical influence; that in fact, their effect is analogous to that of lime. I refer here to the blue clays which are far the most common. As to the white clay I have not learnt its effect upon the soil; but from the fertility of some of the soils in Kingston, Plymouth, and Barnstable, where white clay is mixed naturally with sand, I presume this sort is equally valuable with the blue.

In view of the wide extent of our beds of clay, and the use that might be made of it upon land, I felt desirous to ascertain to what principle it owes its fertilizing powers; and therefore subjected a few specimens to analysis in the ordinary way by solution in alkali. The following are the results. I omit however certain white clays, which I found destitute of iron, and therefore probably not very likely to be of much value upon land. But for other purposes, of which I shall speak shortly, they are of a good deal of importance.

Analysis in the Dry way by Alkali.

No.	Locality.	Water and Organic Matter.	Silica.	Alumina.	Prot-oxide of Iron.	Oxide of Manganese.	Lime.	Magnesia.	Sulphur and Loss.
139	Northfield; blue. . .	10.8	46.93	28.97	9.9			0.1	2.9
140	Sunderland; light blue.	8.2	49.00	29.15	13.1	0.15	slight precip.	0.4	
142	Kingston; white. . .	3.5	71.00	16.30	7.3	0.30	do	0.3	1.3
143	Lowell; white. . .	4.0	61.52	20.50	9.2	0.56	0.56	0.44	3.22

I tried some of our blue clays also, for geine; but in general they yielded only very little, and perhaps none. For so strongly do they retain water, that not improbably all the loss, especially of soluble geine, might have been imputed to this substance, which had not been all expelled by a heat of 300° F.; and then the peroxidation of the iron by ignition, renders this method of analysis quite uncertain. I, therefore, omit the results; only observing, that the amount of sulphate and phosphate of lime obtained, was about the same as in good soils. I therefore suspect that we must impute most of the good effects of clay as a manure to the large quantity of iron which it contains. On this point, however, I will present some suggestions of Dr. Dana, with which he has kindly favored me.

"If we attempt," says he, "to account for the action of *clay*, independent of its amending a sandy soil, we should bear in mind that all our common clays contain more or less of sulphuret of iron. The conversion of this into the persulphate of iron is the natural consequence of exposure: free sulphuric acid then results, which acts on any lime in the soil, forming sulphate of lime: (the Gay Head crystals of sulphate of lime are so formed:) so that by spreading clay, we spread plaster. The iron in clay also plays its part thus. It is evident from Chaptal's experiments, that protoxide of iron is not beneficial in agriculture. He attributes this to the oxidation of the iron, depriving the plant of its intended oxygen. Nature is no niggard; nor is the reason of Chaptal very philosophical. We have seen above that protoxide of iron does not act on geine. Now by exposure, the protoxide becomes peroxide; and then, I conceive begins an action similar to that of lime. If the free sulphuric acid, produced as we have supposed, finds not lime enough, it will decompose all earthy geates, and thus a fresh portion of nutriment is set at liberty. Both the effects of clay—the production of plaster and the formation of peroxide of iron, are speedily produced by burning the clay, as is often practised."*

Still more recently, Dr. Dana adds the following: "Some facts have lately come under my eye, and have recalled others to mind, which I have followed up experimentally; all tending to show, *that if iron peroxidates itself in contact with vegetable fibre, the texture of the vegetable fibre is weakened*, and geine is produced, and that *in a few hours. It is during the passage from protoxide to peroxide that the 'saponifying' action takes place*, geine is produced, and then *combines with peroxide.*"

In the few analyses which I have given above of our clays, I have considered all the iron in them as existing in the state of protoxide; although I made no attempt to ascertain whether some of it might not be a peroxide. Very probably this may to some extent be the case: especially where the clay has a yellowish tinge. Yet for the most part, I doubt not it is a protoxide. A slight error here cannot affect the reasoning above presented.

I hope our farmers will make more numerous and accurate experiments upon the use of clay as a manure; not merely upon sandy land, but following the suggestions of Dr. Dana, upon other soils, in the expectation that its action will be analogous to that of lime. Probably, the best clay for this purpose occurs in the valley of the Connecticut river; but it abounds in almost every part of the state, and perhaps it may in a good measure supply the deficiency of lime. It will of course require to be laid on in much greater quantity than marl, and probably, as in the case of marl, too much may be used. How much ought to be used is a fair subject for experiment.

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* The agency of geine in the fermentation of manure is thus explained by Dr. Dana with his usual clearness and felicity.

"By fermenting dung vast volumes of ammonia are liberated. I do not think that it is the action of gases as such, which we want or which nature intends as food of plants to be derived from the soil. The air is always full of all which this fermenting manure can supply in a gaseous form. The true actions of ammonia and carbonic acid resolve into their effects on geine. The ammonia combines as alkali with that, and thus it becomes very soluble, and the carbonic acid produces sur-salts of the earthy geates of lime and magnesia. It is these, liberated the moment the plant demands them, which cause all the geine of the manure to become alcaline soluble geates."

"How wide is the influence of geine! It not only enters by itself into the food of vegetables but becomes the very solvent which nature has proposed to act on the alcaline earths and oxides, dissolving them as they are liberated from decomposing granitic sand."

8. Decomposing Feldspathic and Micaceous Rocks.

Feldspar and mica contain quite a large proportion of potassa; a substance well known to be valuable in agriculture. And these minerals constitute a large proportion of several of our most common rocks, such as granite, sienite, greenstone, porphyry, gneiss, mica slate, and graywacke. Hence we might predict that these rocks, recently decomposed or reduced to fine powder, would form a good dressing for land; especially when we recollect that the same rocks contain a fair proportion of iron. Now some varieties of them are very liable to decomposition: and when partially crumbled down, if ground in a plaster mill, they will be brought into a proper state for such a use. These suggestions, however, are more the result of theory than of actual experiment: although such a use of powdered rock has sometimes been made and found of value. Indeed, an example of the good effects of decomposing gneiss upon cultivation was pointed out to me in the south part of Athol: and No. 100 presents a specimen of this substance, obtained nearly a foot from the surface in a ploughed field, but not below the point to which geine had penetrated; as appears from the analysis. Yet as this is insoluble it could not affect the vegetation but slightly. The salts of lime also are not in large proportion, and very probably its good effects, which were not represented as great, may have chiefly resulted from the liberation of potassa from the mica and feldspar.

Now there is a great deal of partially decomposed rock in the formations of this State, which have been named above, and they constitute at present the most barren spots in our soils: because they are not reduced fine enough to form a good soil; or because they are too strongly impregnated with stimulating salts. Perhaps if spread over soils already containing geine, they might operate favorably upon crops. At least, it seems to me there is so much plausibility in the theoretical suggestions above made, that it would be desirable to make this experiment on a small scale, since it is so easy, even if it be necessary to reduce the crumbling rock to powder in a mill.

9. HYDRATE OF SILICA.

In describing our marls I have already given some account of this peculiar substance. In its purest state, as it exists in No. 157 from Spencer, it is difficult to distinguish it, except by chemical tests, from carbonate of magnesia, which it exceedingly resembles in its color, levity and taste. When mixed with some vegetable matter, as in Nos. 169, 170, 171 from Barre, Andover, and West Bridgewater, its color is darker. It occurs in many parts of the State in swamps, beneath peaty matter, especially in the extensive gneiss region of Worcester county. And as it has often been mistaken for marl, it has been frequently applied to land. I should not expect from its nature that any important effect, good or bad, would result from it; for in its pure state it is little else than a hydrate of silica; that is, water and silica, as the following analysis of No. 157 will show.

Water	10.00
Silica	86.46
Alumina	2.96
Oxide of Manganese	0.28
Magnesia	0.30
	100.00

I can hardly conceive, that this substance in a pure state should be of much use in agriculture; and yet I have had testimonies of such a character to its value, that there can be no doubt but it is a fertilizer of considerable importance, especially when obtained from beneath peat. It occurs abundantly in the State of Maine, as well as in most other parts of New England; and Dr. C. T. Jackson, the State Geologist of Maine, in a private letter remarks as follows: "It is a curious fact that this substance, so abundant under our peat bogs, acts as a fertilizer to dry soils. Its action, I suppose, is partially due to its hygrometric properties, and partly to its imbibing the juices of peat. It does not contain any lime, but is a sort of siliceous marl, if I may so call it."*

Mr. Alonzo Gray, to whom I am indebted for the specimen from Andover, says: "I have found this substance in three places: in one of them on the surface, in the others beneath peat. One of the beds covers a surface of six acres. The peat upon the top is from 2 to 6 feet thick: then succeeds a vegetable substance mixed with some earthy deposite, from one to two feet, then the supposed marl, 15 feet in depth. The substance immediately under the marl is worth about one half as much as manure for land; and has been used considerably for that purpose. A small quantity of the substance under this was used on land the last year: but not in sufficient quantity to test its use. The gentleman who owns the land, has dug out a large quantity with the intention another year of giving it a fair trial." Probably the stratum which Mr. Gray describes as immediately under the peat, is a mixture of this hydrate of silica and geine derived from the peat; and hence its fertilizing effects. And I presume that wherever this hydrate is dug, that will be found best which lies nearest to the peat. I might mention other cases in which it has been successfully applied to land: but my principal object is to call the attention of our intelligent citizens to the substance. Its situation in swamps, its levity when dry, and its not effervescing with acids, will enable any one to distinguish it from analogous substances.†

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* There has been great confusion in the use of the term marl, and doubtless it has often been applied to substances that contained no carbonate of lime; although its scientific use is now limited to a mixture of carbonate of lime and clay. We want very much a name for several substances, analogous to that described above. Why not call that friable substance in which silica predominates, *siliceous marl;* that in which clay predominates, *aluminous marl:* that in which iron predominates, *ferruginous marl:* that in which lime predominates, *calcareous marl,* and that in which green sand predominates, *green sand marl?*

† For the specimen, No. 170, from Barre, I am indebted to Mr. A. Jenkins, of that place: and for No. 171, from West Bridgewater, to John C. Howard, Esq., on whose farm it was found.

10. SOURCES OF GEINE OR VEGETABLE NUTRIMENT IN MASSACHUSETTS.

Having now pointed out the situation and value, so far as known, of all the calcareous deposites in the State that can be applied to agriculture, and of other substances whose action on soils is somewhat analogous to that of lime, the next grand inquiry is, whether there are any sources in the earth from which additional quantities of geine can be obtained, or matters convertible into geine. I pass by the whole list of common manures, presuming that they will be fully discussed by the Agricultural Surveyor. And I shall merely notice the natural sources of vegetable nutriment within our limits.

Peat Swamps.

The peat swamps of New England have become a vast repository of organic matter, which is, and has been, for ages increasing. In addition to the larger vegetables, which, as they die, fall and are enveloped in the soft matter on which they grew, there is a thick mat of moss, which—especially the sphagnum—continues to flourish at the upper part while the lower part dies and decays. In favorable circumstances as to wet and temperature, this mass of vegetable matter becomes converted into peat. Only a small part, however, of what is thus accumulated, becomes peat of such a character that it answers well for fuel. Often it is too much mixed with mud to be easily burnt, and sometimes the vegetable fibre is scarcely changed. Yet the whole of it is capable of being converted into vegetable nutriment. And I am convinced, from all that I have seen and heard, that Massachusetts contains enough of this geine and vegetable fibre in her swamps, to render all her fields fertile for centuries. In other words, here is an exhaustless source of geine. Some of it is already in a soluble state; and therefore the black matter from swamps, is rarely spread upon soils without producing some benefit. Yet for the most part the geine is in such a state as to require some chemical change before it will become soluble nutriment, fit to be absorbed by roots. It is an important inquiry then, what is the best mode of accomplishing this change. This has been attempted, first, by mixing the peaty matter with good manure in alternating layers, and suffering them to ferment for a long time, the peat being in much the greatest quantity. Secondly, by mixing it in a similar manner with lime; and thirdly, by mixing it with alkali, or some compound containing alkali. The principles respecting geine which have been advanced in this Report, will probably enable us to decide as to the preference to be given to any one of these methods. And here I have it in my power to give the opinion of Dr. Dana, whose remarks I am always happy to substitute for my own, on a subject with which he is so familiar, and which he has done so much to elucidate.

"The fact," says he, "that peat or turf is very soluble, in alkali, seems not to be known among our farmers. The usual practice of mixing lime with peat or turf is decidedly the worst which can be followed. The geine which constitutes a large part of peat bogs, forms with lime a compound little soluble in water, requiring at least 2000 parts of water to one of geate of lime: and if the compound has been dryed and sun-baked, a still larger portion of water is required: it becomes, in truth, almost insoluble. With alumina, geine forms a compound still more insoluble than with lime; and though the vegetable matter in combination with these earthy bases, is actually absorbed by the roots of growing plants, still the geine is in a state much less favorable than when in combination with alkali. Mix ley of wood ashes with peat, and we form a dark brown vegetable solution: the alkaline properties are completely neutralized by the geine, and very often ammonia escapes from turf when treated by caustic alkali. When we add, that this geine absorbs and retains nearly its own weight of water without seeming moist, it is evident, that with the use of ley or wood ashes, the value of peat as a manure will be very much increased."

I will only add, that in my opinion it would be very desirable to have a series of experiments performed by a practical chemist upon the different varieties of our peat, and especially upon the best mode of converting it into soluble geine. Since by the old methods of analysis the different varieties of peat would be found to differ from one another only in the quantity of organic matter which they contain, I supposed it would be useless to analyse them, and therefore did not collect specimens of the peat and other vegetable matters that occur in our swamps. The doctrines respecting geine put a new aspect upon the case, and lead me to regret that such a collection was not made. The labor of doing it now, however, is small; and when it is considered what an immense mass of organic matter now lies useless in our swamps, while the fields around them yield but a scanty crop, and that the chief reason why our farmers make so limited a use of this manure, is, that they find it difficult to convert it into soluble nutriment, I sincerely hope that the government will do all in its power to bring into use this important part of our fossil resources.

Geic Compound. (Apothemite.)

On the farm of Col. Moulton, in the south-west part of Newbury, seven miles from Newburyport, occurs a peculiar substance, which, at first view, is pronounced to be a sort of peat; but, on applying heat, it is found to be something quite different. Its color is a deep brown, hardly to be distinguished, when in mass, from black. When wet, it is soft and unctuous, and exhibits some degree of elasticity; when sundried, it becomes quite hard, and receives a polish from hard substances. Before the blow-pipe, the coloring matter disappears and a white enamel is formed. From an accurate and very satisfactory analysis which Dr. Dana has made of this substance, it appears, so far as I know, to be a new and undescribed compound. His analysis is as follows:

Water,	13.500
Geine,	19.625
Silex,	36.908
Alumina,	19.197
Peroxide of Iron,	8.826
Sulphat of Lime,	1.542
Magnesia,	.402
Specific Gravity, 2.08	100.

"The earths and oxides," he remarks, "are such as we might expect from the decomposition of trap or greenstone: the geine, I presume, has been gradually deposited from the solution of vegetable matter in water. It has precipitated chiefly in combination with peroxide of iron, forming *pergeate of iron*. The sulphate of lime is doubtless derived from vegetable decomposition. It enters largely into the composition of the grasses; and all our waters, whether of ponds, rivers, or springs, contain, so far as I have examined, traces of sulphate of lime. The black coloring matter, or geine, is readily soluble in carbonated or caustic alkali: and keeping this fact in view, I think that, mixed with wood ashes, the above substance will form a very valuable manure, particularly where the soil is light and sandy."

This geic compound at the locality above named, forms a layer from six to eight inches thick, and sometimes more, over several acres of a deep, basin-shaped cavity, which is nevertheless dry enough to plough. It did not seem to exert any fertilizing effect upon the soil in that place, but rather the reverse, though on this point I made no inquiries. But probably the geine is too strongly bound to the iron and alumina to be given up without the action of an alkali. Dr. Anthony Jones of Newburyport informs me, that he knows of two other places where this substance is found; one of which is on the north side of Merrimack river, in Amesbury. Indeed, there is every reason to believe, that it will be found in many places in Essex county, where sienite prevails, and it may, therefore, become an object of no small interest in agriculture.

The astonishing power of this substance to absorb water, may be learnt from the fact, that while it appears from the table that has been given, that 100 grains of no soil absorbed, in 24 hours, quite seven grains, 100 grains of this compound absorbed 19.1 grains. This fact shows us that the absorbing power of soils depends much more upon the quantity of geine which they contain, than upon any other ingredient.

Use of this Substance as a Paint.

This geic compound, with no other preparation than that of drying, has been employed as a paint, mixed with oil. It is said to answer a good purpose; and at Col. Moulton's I saw some wood-work covered with it, which appeared well. The color is so deep a brown that it passes very well for black.

It answers, also, as a water color, on paper. By simply grinding it in water and using it for a landscape, the color could hardly be distinguished from that called sepia. Through the kindness of John Tappan, Esq., of Boston, I obtained the following opinion respecting this substance, of a distinguished manufacturer of water colors in New York, to whom it was sent in a crude state, with no information respecting its nature or origin. By simply suspending it in water, it will be easy to obtain a much more delicate variety for the purpose of painting; and as it will probably be found of different shades of color at different localities, it may perhaps be an object to perform some experiments of this sort; for it may prove that it will be more valuable as a paint, than in agriculture.

"The sample of color," says the manufacturer, "which appears to be a variety of lignite, might probably be of some use, as a deep brown color, for common purposes; but does not appear to have any extraordinary richness or body. It is not sufficiently *brown*, for either sepia or cologne earth, (or vandyke brown), and it is too brown to be sold for black. But if it could be sold quite low, it might come into use for a brown black, or deep brown."

For this geic compound, which appears to be well characterised, Dr. Dana has suggested the appropriate name, *Apothemite*: apotheme being the term applied by Berzelius to a deposite of geine, &c. in vegetable solutions.

11. SUBSTANCES YIELDING BOTH GEINE AND SALTS OF LIME.

I shall delay for a short time upon two other substances, abundant in the state, which may be of no small use in improving our soils, by affording both geine and the salts of lime.

Marsh Mud.

Every intelligent farmer probably knows, that this substance forms an excellent manure; although I apprehend it is employed far less than its value demands. An intelligent farmer in Maryland states, that he "deems it more valuable than barn-yard manure;" and that "it never failed in any application he had made of it." He also prefers it to marl, because "it is more accessible, its effects are quicker and much more can be done in the way of improvement for the same money." At the same time he confesses, that the permanent advantages of marl are much greater; and thinks that marl and marsh mud will both be improved by combination."* This last remark appears still more important, when we ascertain what it is that gives an agricultural value to this substance. The fact is, it sometimes contains a large quantity of geine, and sometimes but little, while the quantity of the salts of lime, soda, and magnesia, is rather large; so that sometimes a mixture of marl will be of service, and sometimes not. The following analysis of a few specimens of marsh mud, both in the ordinary way and by Dr. Dana's method, will show us, I think, what it is that constitutes its fertilizing power, and afford some useful hints as to its application.

Analysis in the dry way by Alkali.

No.	Locality.	Water of Absorption.	Organic Matter.	Silica.	Alumina.	Oxide of Iron.	Lime.	Magnesia.	Salts soluble in Water.	Sulphuretted Hydrogen & Loss.
135	Newburyport, . .	3.2	3.3	68.1	14.7	7.4	2.0	0.8	0.2	0.3
136	Medford, . . .	9.5	12.5	50.95	14.9	8.15	1.1	0.2	0.6	2.1

Analysis by Dr. Dana's Method.

No.	Locality.	Soluble Geine.	Insoluble Geine.	Sulphate of Lime.	Phosphate of Lime.	Granitic Sand.	Specific Gravity.
134	Cambridge, ...	13.0	7.4	2.3	0.4	76.9	1.92
135	Newburyport, . . .	1.5	0.1	3.0	0.5	95.1	2.52
136	Medford, ...	7.5	5.6	2.6	0.3	84.0	1.92

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* Farmer's Register, July 1834; p. 93.

A substance so rich in geine, or salts of lime and soda, or in both, as the above analyses show, cannot but prove a fertilizer of the soil if spread upon it. If a soil be quite poor, those varieties should probably be chosen that contain the most geine; and this can be judged of by their comparative lightness when dry; the lightest abounding most in organic matter. But if the soil already contain a good deal of inactive vegetable matter, the varieties that abound most in salts will probably be most efficacious; though an additional quantity of geine can do no harm, and may do much good. If marsh mud be applied at random, it is not strange that varieties of it, almost destitute of geine, should be sometimes put upon exhausted soil, and that no good effects should follow. Hence the necessity of some fixed principles to guide the farmer. And since Massachusetts contains so much sea board, and so much land near the coast that may be benefited by this substance, a correct mode of applying it is of great importance.

Muck Sand.

As this substance has never been proposed for use in agriculture, it will be necessary to state the circumstances that have led me to bring it forward in this place.

Nine or ten years ago, Luther Root, Esq., Cashier of Amherst Bank, had occasion to dig a well in his garden in Sunderland, where he then resided. This was only eighty rods from Connecticut river, and the land there is alluvial to the depth of more than twenty feet. Near the bottom the excavation passed through a thick stratum of what is usually called quicksand, and which on being thrown out emitted a strong odor of sulphuretted hydrogen. It not being convenient to remove all this earth, it was spread upon a considerable part of the garden, which was a good soil and always well manured. He was warned against doing this, lest it should ruin his garden, and he thinks the quantity spread was not greater than a good coat of manure. The part thus covered was mostly planted with watermelons and other vines: and, instead of injuring the spot, it produced so great an increase of fertility as to astonish himself and his neighbors, and to lead them to search the banks of the river and low places for a similar substance. The good effects continued for two years, and afterwards declined, so that in a year or two the land thus treated was not better than the other parts of the garden.

Seventeen or eighteen years ago, Mr. Rufus Rice had occasion to dig a well on his farm in South Deerfield; and after passing through six feet from the surface, he struck upon what he describes as quicksand, though dry at the time he dug it, and probably mixed with clay. He represents the substance dug out when wet to be almost as much disposed to flow as water, and that it was very difficult so to wall up a well with stones that this sand would not pass through and fill it. He describes it also as giving out a strong odor, and a small quantity which he showed me, that had lain for fifteen years, still retained that odor, and appeared to be identical with the *muck sands* to be described in this Report. Wishing to remove the sand thus thrown from a well twenty-two feet deep, and having understood that the effect of a change of soil was good, he carted five loads, after it had lain exposed for a year, upon a piece of ploughing, spreading it about as thick as a good coat of manure. This was in the autumn; and the next spring the whole piece was planted with Indian corn, after having been manured in the hill. But that part of the field, which had received the muck sand, soon began to show a much more thrifty growth than the other, and yielded a greater crop. From that time to the present, corn, oats and clover, have been the rotation of crops every three years, except that two crops of rye have been raised upon it, and whenever it was manured, all parts were spread over alike. And even up to the present time, the part on which the muck sand was spread, seventeen years ago, continues to show decidedly more fertility than the other part. I saw this difference last autumn in the crop of Indian corn then growing, and it was considerable.

A few rods from the spot where the well above noticed was dug, another had been excavated three years previously to the depth of eighty feet, and a large quantity of the muck sand, with perhaps some clay, lay upon the surface; although the well itself had been filled by the caving of the sides. Mr. Rice carried from five to ten loads of this upon a spot of dry mowing, which had almost ceased to produce grass. It was spread about as thick as a good coat of manure, but with no mixture of manure, some time in June. On the first crop of grass that year it produced no effect, and there was not enough grass to be worth gathering. But the second crop was a very heavy one, and consisted mainly of clover, although the clover had previously disappeared. The next year the first crop was equally good, the second not so large, though better than middling. In subsequent years the good effects became less and less obvious: but they were visible at least ten years.

The facts communicated to me by Mr. Root (those respecting Mr. Rice's experiments I did not learn till somewhat later) seemed to furnish a clue that might lead to results of considerable importance.

But the substance that produced such effects upon the soil had all disappeared from the surface, and could not be obtained from the wells. It occurred to me, however, that the same stratum must extend from Sunderland village to Connecticut river; and that its outcrop might be found there, as the bank is more than twenty feet high. A gentleman acquainted with the substance accompanied me thither; and we soon found a stratum of sand several feet thick, which he recognized at once as identical with that dug from the well. Having seen it in one place, I was able to trace it in others. I examined the banks of Connecticut river across the whole state; and wherever they are alluvial, I almost uniformly found this stratum from ten to twenty feet below the general surface. I traced it, also, in many places, in the banks of the Housatonic and Merrimack, the Deerfield and Westfield rivers, and indeed on almost every stream large enough to form much alluvial deposition. On the small streams its depth beneath the surface and its thickness are less. But its leading characters are alike, and somewhat peculiar: and as they made it easy for me to find the stratum, I think I can point them out so that others will be able to recognise it.

The specimens of this substance in the State Collection (Nos. 126, 127, 128, 129, 130, 131, 132, 133) convey but an imperfect idea of its appearance in its native situation, where it is almost always very wet, and generally exhibits a slightly greenish tinge, though perhaps this results from its mechanical rather than its chemical characters. In the banks of our streams, this stratum is the first one from the surface that arrests the water in its descent into the earth; and hence water is seen oozing out from it in almost every place. It frequently lies immediately above a stratum of gravel. It is also remarkable for its yielding nature when wet; it being easy to run a pole several feet into it, and unless covered with turf, a man in walking over it will sink into it several inches. The cause of its arresting water in its descent, and also of the extreme mobility of its particles among themselves, is probably chiefly dependent upon the fineness of its texture, and the form of its particles, rather than upon its chemical composition. When an attempt is made to dig into it with a spade, or trowel, it conducts very much like soft suet. And yet its composition is decidedly sandy: and therefore I call it *muck sand*, although it generally goes by the name of *quick sand*.

Another important character is, that when fresh dug, this substance almost invariably gives out the odor of sulphuretted hydrogen: that is, an odor considerably resembling that of a gun barrel which has been fired repeatedly with gunpowder. Very frequently, also, there is seen oozing from it a reddish matter of the color of iron rust, and which indeed is the oxide of iron, proceeding probably from the decomposition of the sulphuret of iron, whereby the sulphuretted hydrogen is produced. I am inclined to believe that the odor of the sulphuretted hydrogen is so connected with its fertilizing properties, that I doubt whether any sand, not giving it out, will prove efficacious.

It should also be mentioned, that vegetable matter, even sometimes in the state of vegetable fibre, is generally present in the muck sand. Indeed, it seems to be the only stratum, which I have found deep in the earth, that contains much organic matter. In short, it does not differ, so far as I can ascertain, from the rich deposites of mud and vegetable matter, that are now often formed by our streams at high water, except that it has been for a long period in the earth, and thus many important chemical changes have taken place in it, and it has also been the recipient of all the soluble matter, which has percolated from the strata above, but which this stratum has arrested.

These remarks will I trust not only enable others to identify this substance, but will form also the groundwork of a theory that will explain its fertilizing power. This, however, will be better understood when I shall have presented analyses of several specimens by both the methods described in this report.

Analysis by Alkali.

No.	Locality.	Water of Absorption.	Organic Matter.	Silica.	Alumina.	Oxide of Iron.	Lime.	Magnesia.	Salts soluble in Water.	Sulphuretted Hydrogen & Loss.
126	Sunderland,	3.8	3.5	64.01	15.03	12.04	0.10	1.16	0.10	0.26
130	Sheffield,	2.0	2.0	70.68	11.61	10.10	0.80	1.63	0.15	1.03
132	Amherst,	4.0	5.0	64.34	13.5	12.00	0.06	0.90	0.20	
133	Leominster,	1.5	0.5	73.31	14.25	8.14	1.00		0.10	1.2

I have been favored, also, with the following analysis of the muck sand (No. 129) from Hadley, by Dr. Dana.—100 grs. after ignition to drive off the water and organic matters, yielded

Silica,	71.008
Alumina,	16.706
Oxide of iron,	6.202
Lime, with some sulphate of lime,	3.336
Magnesia,	1.552
Traces of manganese and potassa, and loss,	1.196
	100.

Analysis by Dr. Dana's Method.

No.	Locality.	Soluble Geine.	Insoluble Geine.	Sulphate of Lime.	Phosphate of Lime.	Granitic Sand.	Specific Gravity.	Gain of 100 grs. in 24 h'rs after heating to 300°.	Propor'l Absorbing Power.
126	Sunderland, Ct. River,	2.1	3.0	1.0	0.9	93.0	2.57	2.1	42
127	Bradford, Merrimack Riv.	0.8	3.1	0.6	0.7	94.8	2.48	1.8	36
128	W. Springfield, Ct. Riv.	4.1	0.2	3.0		92.2	2.68	1.5	
129	Hadley, Fort River,	2.9 3.09	3.2	1.4 2.25	0.3	92.2	2.60	1.9	38
130	Sheffield, Housatonic Riv.	1.0	2.1	1.9	0.2	94.8	2.63	1.4	28
131	Northfield, Ct. River,	1.9	1.8	1.2	0.2	94.9	2.46	1.0	20
132	Amherst, Fort River,	6.3	0.0	1.2	0.7	91.8	2.39		
133	Leominster,	0.4	2.3	1.0	0.5	95.8	2.68	0.4	8

It will be seen that in the case of the muck sand from Hadley, a double analysis is given. The latter was furnished by Dr. Dana, who did not obtain the insoluble geine, nor separate the phosphate of lime from the sulphate. I give both results, partly because it is the only example which I am able to present, in which my analysis by this new method can be compared with that of another individual.

The specific gravities given above show that in general the density of these muck sands is greater than most of our soils, as we might expect from the fact that they are very sandy. The two last columns show that their power of absorbing water is small; which result also we should expect for the same reason. I regret that my experiments upon the power of these muck sands to retain water, are as imperfect as upon the soils, since we should rather expect that this might be considerable and of some service in agriculture. So far as the trials which I have made enable me to judge, they favor this presumption, though they do not indicate any remarkable retaining power. Thus, on the 20th of January, 200 grs. of the following soils and muck sands, with 100 grs. of water added, were exposed three hours to the sun, from 11 to 2 o'clock, clear and wind westerly, and they lost as follows:

No.		Loss.	No.		Loss.
3	Alluvial Soil,	69.7 grs.	114	Sienite Soil,	54.4 grs.
4	do	69.4	115	do	66.8
5	do	70.0	116	do	57.6
6	do	68.7	118	do	61.0
7	do	71.6	119	do	63.6
15	Tertiary Argil.	66.7	121	Porphyry Soil,	66.3
16	do	69.2	123	Greenstone Soil,	64.4
18	do sandy,	78.8	127	Muck Sand,	50.0
20	do do	67.7	129	do	50.1
23	Sandstone Soil,	68.0	130	do	51.4
24	do	56.6	131	do	56.2
26	do	70.1	132	do	47.1
27	Graywacke Soil,	70.1	134	Marsh Mud,	51.0
30	do	56.3	135	do	52.9
31	do	55.8	136	do	51.9

From the water in which some of the muck sand from Sunderland had been boiled, pure ammonia, as well as carbonate of ammonia and phosphate of soda, threw down slight precipitates. Hence I infer the existence of some soluble salt of magnesia, probably the sulphate. But in no other specimen did any such result follow the application of these tests. The proper tests, however, detected in them all sulphate of lime about in the same quantity as in most of the soils. Its amount may be seen in the table of analysis of the muck sands by alkali.

The preceding analyses appear to me to show that there is no single ingredient in these muck sands that will explain their fertilizing power. But there are several circumstances that probably conspire to such a result. Most of them contain a considerable amount of soluble geine, as well as of the sulphate and phosphate of lime; and I ought to remark in respect to some of them, that they were obtained in places which are exposed to the action of water a considerable part of the time, which may have abstracted a portion of the salts and the geine; as I took them from a few inches below the surface. This was the case with the specimens from Northfield, Bradford, and Sheffield. The others were obtained at a greater depth from the surface. That, for instance, from Amherst, which yielded so large a proportion of soluble geine, was taken from an excavation just made several feet deep. This circumstance should be kept in mind, if any of our farmers should think it best to make any trial of this substance. I hope they will take care to dig to a considerable depth to obtain it, although I should presume that two or three feet would be sufficient where the muck sand shows itself on the banks of streams; and yet the constant percolation of water from this stratum may carry off some of the fertilizing matters from I know not how great a horizontal distance.

In addition to the above circumstances, it ought to be borne in mind that this muck sand, on account of the minute division of its parts, is in the best possible state for enabling the roots of plants to act upon and absorb nutriment. Nor should it be forgotten, that in all cases when fresh dug, these sands give off the odor of sulphuretted hydrogen; which probably proceeds from the decomposition of sulphuret of iron, or some alkaline sulphuret, by the free sulphuric acid formed in the manner described by Dr. Dana, in giving a theory of the action of clays in agriculture. Very probably this sulphuret of iron may act an important part in fertilization by these muck sands;

and hence it is desirable not to use any, certainly in early experiments, which does not emit the odor above named.

These considerations, with the facts that have been detailed, excite a hope that this muck sand may prove an article of no small value as a manure. The specimen from Leominister, however, given in the preceding table, should be noticed as deficient in some points, which, according to the preceding views, are important. It has little if any soluble geine, and the salts are in small proportion. That specimen was received from Mr. Sewall Richardson, who says that it was taken seven feet below the surface, and that it has been dug three years, and exposed to atmospheric agencies. It may, therefore, have lost some of its fertilizing properties. Yet he says, "for the last four years I have applied it as manure on dry land, and find that it produces a good effect. One quart, applied to a hill of potatoes before hoeing, seems to prevent the effects of drought on the driest of our plains, and makes them yield potatoes equal to the best of our land." He says, also, that "it has as much effect on the skin, when first dug and dryed, by handling it, as lime, or ashes." It was in consequence of these statements that I subjected this specimen to analysis; although it bears but little resemblance to the muck sands in general.

The wide diffusion of this muck sand in the state, makes me more desirous of having it tested. I have already remarked that it may be found on the banks of all our streams, which have deposited alluvium. And I doubt not it may be found in most swamps; especially those that are underlaid by clay. From the banks of rivers it might be carted at a season of the year when the water is low, since the stratum usually lies but little above low water mark: and from other places excavated on purpose, it might be obtained at almost any season. Should only a small part of the fertilizing effect result from its use generally, which the facts detailed would lead us to expect, I should still feel amply repaid for my labor devoted to the subject.

Beneath the vegetable matter in most of our swamps, there is a fine sand, quite analagous in appearance to the muck sand that has been described; and from some facts that have come to my knowledge, I suspect that this possesses, in part, at least, the fertilizing character of the muck sand. It probably contains some soluble geine and salts of lime, and sometimes gives off the odor of sulphuretted hydrogen; though perhaps this may result from decayed vegetables, as these sometimes emit an odor resembling that gas. I apprehend that this sand may be found often to possess enough of a fertilizing character to be profitably employed upon land.

Concluding Remarks upon Soils.

Though I have dwelt so long upon the analysis and improvement of our soils, it will be seen that I have touched only a few of its more important features, and that even these are but imperfectly considered. Many minor points, of no small importance, however, have been wholly passed over, or only alluded to; and sensible that I cannot do them justice at present, I shall not attempt to discuss them. My great object has been, after ascertaining the greatest deficiencies in our soils, to satisfy the Government that we have the means of remedying them and of making great improvements in them, by the aid of chemistry. If I may hope that I have accomplished this object, then I take the liberty to inquire, whether it be not important enough, and whether there is not enough still left to accomplish respecting it, to make the appointment of a *State Chemist* desirable? We ought to have still further experiments made on the subject of geine, and the salts, which the soils contain: also accurate analyses of the crops grown on soils with different manures; and investigations as to the manner in which calcareous matter acts upon vegetable and animal substances: as also experiments directed by an able and experienced chemist, on the best mode of bringing into use the vast deposites of geine and vegetable fibre which our state contains. And since we have chemists of this character among us, why should not the services of at least one of them be secured for this object? The geological surveyor might often collect substances for analysis; but if obliged to go as thoroughly into the chemistry of the subject as is necessary to valuable results, he cannot within any reasonable time accomplish the more appropriate objects of his appointment. In at least one state of the Union, where geological surveys are in progress, one gentleman is appoint-ed, whose time and attention are exclusively devoted to the chemical examination of the soils, ores, &c., collected. And I would fondly believe, that Massachusetts will not rest satisfied, till this work is done at least as thoroughly as in any other state. I believe there is abundant labor for an experienced chemist upon our soils alone: but many other substances, found in the state, ought to be analysed, that their real value may be known.

I do not doubt but the Government and every intelligent reflecting citizen will feel the vast importance of energetic efforts to improve our soils so that they may sustain a larger population. This is the only way to check the tide of emigration that sets so strongly to the great West. For if our sons can be made to see the soil of New England doubling its increase, as I verily believe they might in one or two decades of years, the rich alluvia and prairies of the West will not be able to draw them away from the graves of their fathers; especially if they learn that those fertile regions will at length become exhausted of their geine and salts, and then will probably require as much labor to cultivate as the soils of Massachusetts.

Some, however, may contend, that it is more important, to transfer the New England character to the unsettled West, than to multiply our numbers and wealth at home. But the history of the world leads us to fear, that New England character cannot long be preserved except upon New England soil; or upon a soil that requires equal industry for its cultivation. Place New England men where the earth yields spontaneously, and the locks of their strength will soon be shorn. If we look over the map of the world, and the history of the past, we shall find as a general fact, that the brightest exhibitions of human character have been made, in regions where nature has done less, but art and industry more. If, therefore, we wish to increase the moral power of New England, it must be done by improving her soil, and increasing her resources and her population. If these views are correct, which I acknowledge do not fall in with the prevailing notions, they furnish a new stimulus for vigorous effort in the improvement of our soils.

12. Fossil Fuel.

Next in importance to the means of improving our soils, I have regarded the discovery of fossil fuel; that is, fuel dug out of the earth, and resulting from vegetables which have been buried there in former times; and, therefore, I have examined with no small care, every spot where such discovery seemed likely to be made. When I prepared my former Report, I confess my expectations were not sanguine that Massachusetts contained within her bosom any extensive deposites of coal; though aware that not a little peat might be found. But since that time, the enterprise and industry of some of our citizens have put quite a different aspect upon the subject, so far as coal is concerned; and I have made such extensive inquiries respecting peat, as leads me to suppose its quantity in the state has been much underrated. I will now proceed to give such details as will enable the Government to form an opinion on the subject.

Anthracite Coal.

In my former Report, I stated that, "we might reasonably look for anthracite coal in any part of the greywacke formations exhibited on the Geological Map." This extends in interrupted patches across the whole of the eastern part of the state, and at its southern extremity, embraces the coal beds of Cumberland, Rhode Island. I also marked on the Map beds of this anthracite in the east part of Cumberland, Rhode Island, and in Middleborough, West Bridgewater, and Wrentham, Massachusetts. In the autumn of 1835, since my Report was published, another bed was discovered in Mansfield, which led to the formation of "the Massachusetts Mining Company," "the Mansfield Mining Company," and "the Mansfield Coal Company," all of which have exhibited great and commendable perseverance to make explorations in spite of the general stagnation of business and enterprise; and their efforts have been crowned with far greater success than I could have anticipated. I shall describe the principal excavations that have been made by these companies in that region, with the results to the beginning of last October.

The Massachusetts Mining Company commenced their explorations in 1835, on the farm of Mr. Alfred Harden, where a shaft sunk only 25 feet, struck a bed of coal 5 feet wide, and another only 1 foot thick, separated from the first by 10 inches of rock. The shaft has since been carried to the depth of 64 feet; and from the bottom of it, in opposite directions and following the bed of coal, drifts have been extended 150 feet, and rail-ways laid for bringing the coal to the bottom of the pit, from whence it was, until recently, raised to the surface by a windlass and hand power; but steam power is now used, which greatly increases the daily amount of coal raised. About 1,500 tons had already been raised from this mine, when I visited it in October; and a drift had been carried from the bottom of the shaft, in a south-east direction, several feet across the rock strata, in search of new beds. Only one about a foot thick had been reached.

The explorations at this spot have been carried forward under the direction of Gen. Samuel Chandler, of Lexington, who seemed to me to have managed the whole concern with remarkably good judgment, and to have brought the principles of science to bear upon practice with singular success. In his printed Report to the Company, he says, that "although the region has been but very imperfectly explored, even where the strongest external evidences appear, yet four separate veins are known to occur on land leased to the Massachusetts Mining Company, situated at no great distance apart, and parallel in their line of bearing: two of which have been opened sufficiently to ascertain their thickness to be over five feet," &c.

The clerk of the company, William B. Dorr, Esq., makes the following statement in respect to these explorations, which must be regarded as very encouraging. "The Massachusetts Mining Company," says he, "at an expense of less than $15,000, with all the discouragements of a novel undertaking, the almost entire want of practical knowledge of the subject, and the cost of experiments which experience would have rendered unnecessary, have been able to raise from 1200 to 1500 tons of coal, worth from $5000 to $6000, at the lowest estimate both of the quantity mined and of its true value." "The directors have unhesitating confidence in the eventual success of the mining operations at Mansfield; and nothing but the universal prostration of enterprise and business, has prevented their pursuing these operations on a scale commensurate with their confidence and the public importance of the subject."*

There are two methods of ascertaining the value of this coal for fuel: both of which it is desirable to be applied. One is chemical analysis; by which we learn how much carbon, or combustible matter, it contains, and how much earthy residuum that is useless: and the other is experience in using it. In 1835 Dr. C. T. Jackson analysed two specimens taken from the depth of about 25 feet, and the results were as follows:

1st specimen.		*2d specimen.*	
Carbon,	98	Carbon,	96
Peroxide of iron and alumina,	2	Peroxide of iron and alumina,	4
	100		100

I have made but two trials with a specimen obtained at the mine last autumn, and the result is as follows:

1st specimen.		*2d specimen.*	
Carbon,	94	Water,	5.6
Residuum,	6	Carbon,	88.8
		Residuum,	5.6
	100		100.

Specific Gravity, 1.70.

The amount of carbon in these specimens is a little greater than Prof. Vanuxem obtained from two specimens of anthracite from Rhode Island. In one he found an earthy residue of 5.07 per cent, and in the other of 15.60 per cent. He also found about the same per cent of water as I obtained in the second trial; this item having been neglected in the first trial, as well as by Dr. Jackson, as our chief object was to ascertain the amount of earthy residuum. The amount of carbon in the Mansfield coal is nearly equal to that in "the purest anthracite of Lehigh," in which Prof. Vanuxem found 3.3 per cent of earthy residue, and the mean of the four analyses given above is only 4.4 per cent of residuum. The composition, then, indicates the very best kind of anthracite. Its specific gravity, however, is 1.70; while a specimen of Peach Mountain, in Pennsylvania, was only 1.49; and hence, perhaps, we might expect some more difficulty in producing perfect combustion in the former than in the latter.

As to the testimony which experience gives to the value of this coal, so far as that testimony is within my reach, it corresponds to what chemical analysis would indicate. It ought to be recollected, however, that beds of coal near the surface of the earth, are always more or less affected by the action of water, which insinuates itself into their crevices. I have understood, that from this cause the coals of Pennsylvania have improved since the beds were first opened. It ought also to be recollected, that coal from a new locality may be expected to require a little different mode of management to make it burn well; and also that when men do not find such new article to conduct precisely like that which they have been accustomed to use, they are apt to infer at once that it must be of an inferior quality; and they are not willing to be at the trouble of making experiments to get over the difficulty.

"The quality of this coal," says Gen. Chandler, "has given very good satisfaction generally to the purchasers, notwithstanding it was taken by many under unfavorable circumstances."—"Many competent judges who have had opportunities of testing its qualities thoroughly, represent it equal, in their opinion, to the Pennsylvania Anthacite in all its essential properties."—"The fine coal has been taken in considerable quantities and used as fuel for steam power, and proves to be a very superior article for that purpose, &c."

Foster Bryant, Esq., of Mansfield, who appears to be very familiarly acquainted with all the mining operations in that region, states, that as the beds have been explored to greater depth the quality of the coal has improved, which he imputes to the action of the water upon the upper portion of the beds. This often prevents the thorough combustion of the coal, although it ignites without difficulty and burns well for four or five hours. He adds, that "the coal of Mansfield, even in its present impure state, is capable of being converted to all economical purposes, and contaminated as it now is by adventitious substances, it is a better, far better article, than the coals from the Little Schuylkill were in 1831, and altogether better than the first year's produce from the Lackawana mines."

"The quality of the coal," says Mr. Dorr, "has afforded entire satisfaction to those who have taken the pains to give it a thorough trial, and to investigate its distinctive properties. Several of the directors use it exclusively for fuel, in open grates, cylinder stoves, and cooking ranges. It is found to ignite and burn best with a very moderate draught; and broken to about the size of a butternut. Uniformity in size is of course desirable. Under favorable circumstances, little difference is found in comparison with the best Pennsylvania anthracite, whether in relation to facility of ignition or intensity and durability of heat."

"The community generally, from feeling less interest in its success than the proprietors, will naturally take less pains in its use; and like every new discovery, its general introduction will doubtless be gradual."

The following testimony was given by the captain and passengers of the steamboat President, where the Mansfield coal was used, on a trip from Providence to New York:

New York, Dec. 25, 1836.

Dear Sir:—I received the sample of the Mansfield coal yesterday, which you sent to me for trial on board the President. I used it on the passage from Providence to New York, in the various kind of stoves we have on board, and was much pleased to find that it burnt very freely, making quite as hot a fire as any Anthracite coal hitherto used on board this boat. I consider it superior in quality to many kinds of Anthracite coal now in use in this city.

I am, very respectfully, your friend,

ELIHU J. BUNKER.

To Mr. Foster Bryant.

Steamboat President, Dec. 24, 1836.

The undersigned, passengers on board the President, from Providence to New York, with pleasure bear testimony to the excellent quality of the Mansfield coal, with which the cabin fires were supplied during the trip. So far as they are able to judge, the article from Mansfield, used in the cabin, is fully equal to the Pennsylvania coal in all essential properties.

Richard Rankin, Frankfort; Thomas Lovett, Boston; John S. Barker, Lt. R. S., Newport; James S. Peters, Cortlandt, N. Y.; Benjamin Morse, New Fairfield, Conn.; George H. Riddell, Nantucket; Thomas B. Griffith, N. Y.; John Clark, Jr., Boston; Charles Howes, Boston; Thomas Ayling, Newtown; Daniel H. Johnson, Salem, Mass.; E. Nottebohen, Boston; John P. Davenport, do.; J. B. Hastings, do,; Joseph Pond, Philadelphia; Levi Pratt, Fitchburg; George H. Owman, Providence, R. I.; Henry B. Lloyd, Boston; John Whipple, Providence; Thomas Hopkinson, Lowell, Mass.; J. A. Etheridge, Dedham; G. M. Peck, Freeboro', Mass.; H. Sumner, Foreboro', Mass.; G. L. Brown, Providence; William Power, Bristol; Charles N. Cogswell, S. Berwick, Me.; George W. Lathrop, West Bridgewater, Mass.; Edward Ritler, N. Y.; B. G. Snow, do.; E. P. Robinson, do.; J. H. Tuck, Nantucket; Benjamin Morrill, Boscowen, N. H.; William S. Eastman, Baltimore; Thomas B. Parks, Berwick, Me.; Joseph Matthewson, Providence, R. I.

I have shown that the coal of Mansfield, and of Portsmouth, R. I., is embraced in the same general and continuous rock formation. Hence we have every reason to believe that the coal from every part of this great field will be essentially alike. Now the Portsmouth coal was formerly used to a considerable extent, and very fair experiments were made by Professor Silliman, (which I have detailed in my former report,) to ascertain the value of this coal for common fuel, as compared with that from Pennsylvania; and he comes to the conclusion that there is no important difference between them. There can hardly be a doubt, but the same conclusion may be safely applied to the Mansfield and Pennsylvania coal.

Exploration of the Mansfield Coal Company, and the Mansfield Mining Company.

The Mansfield Coal Company have simply sunk a shaft 64 feet near the centre of Mansfield, but have met with only a little coal: another shaft was sunk, half a mile north-west of the Harden farm, by the Mansfield Mining Company, to the depth of 84 feet, in which a bed only a few inches thick was crossed. A drift was then commenced at the bottom of this shaft, horizontally, towards the south-east so as to cross the strata. This had not been pushed far, when a bed of coal was struck, which, at the place, was about 10 feet thick; though on exploring it laterally for a few feet, it was found to be somewhat irregular; as indeed most of the beds are in the region, and as they are in fact in all coal fields. In crossing this vein, 25 tons of coal were thrown out, some of which is of a very superior quality; as may be seen in the collection (No. 207.) For specimens I am indebted to Mr. Joseph D. Clapp, the agent, who informs me that this vein has received the name of the "Wading Vein." When I visited it in October it had recently been discovered, and I have not since learned whether it has been pursued farther. I subjected 100 grains of it to analysis with the following result.

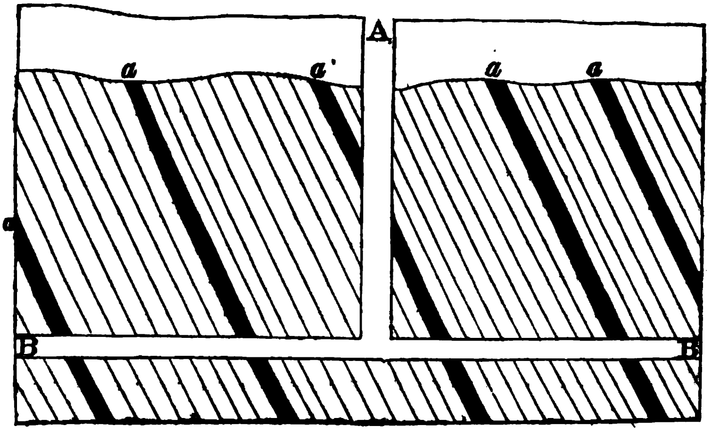
Carbon, ...	96
Alumina, Iron, &c., ...	4
	100
Specific Gravity, ...	1.79

We have seen, from the testimony of Gen. Chandler, that four distinct beds of coal are already known upon land leased to the Massachusetts Mining Company. Mr. Foster Bryant states, that "seven distinct veins of coal have been struck in Mansfield, and the strongest indications are found of five more, one of which, from its great breadth is probably a continuation of the great vein at Cumberland." This is a great number to be discovered so early. For it ought to be stated that the whole of that region is covered by a coating of diluvial earth nearly 20 feet thick; so that it is only when in digging a well, or other excavation, that much chance exists for discovering the coal: for I could not learn that any streams in the vicinity have cut through this diluvium. The fact that with such peculiar difficulties in the way, so large a number of beds have been discovered in the space of a little more than two years, is to my mind a very strong proof that the region of Mansfield is likely to prove a very rich and valuable coal field. By looking at the Geological Map of the State it will be seen that the greywacke formation embraces a large part of Bristol and part of Plymouth counties, as well as a part of Rhode Island. All this space which Mr. Bryant estimates at more than 400 square miles, is to be regarded as a coal field; and indeed, on the northern side, which is nearly 30 miles long, coal has been found in various places through the whole distance. A very large part of this extensive region is covered by a thick coat of diluvium, as in Mansfield; and where rocks appear in place above the surface, they are those varieties of the greywacke which are least likely to contain coal, being coarse and hard. The coal usually occurs in fine dark colored slate, alternating with gray sandstone: and these are very liable to be disintegrated and worn away. Hence, the best prospect of finding coal is where the rock is most worn away, and the soil deepest. Such is the rock every where found in Mansfield, and since an almost perfectly level plain exists there, over many square miles, I infer that the rock is very similar over its whole extent; and hence that probably we may hope for more success in explorations there, than in almost any other part of the coal region above described.

It is a fortunate circumstance that the great Rail-road from Boston to Providence passes across the centre of the plain of Mansfield, and within 80 rods of the Harden farm, where the most extensive exploration has been made. From this spot it is 15 miles to Providence, 11 to Taunton, and 26 to Boston. A more favorable situation could hardly have been chosen for the location of this coal, had the proprietors themselves selected the site.

Coal rarely if ever occurs in *veins*, properly so called: that is, occupying fissures *which run across the layers of the rock*. But it is uniformly found lying *between* the layers of the rock; that is, in what are called *beds*. If the layers of the rocks are horizontal, the beds will be horizontal. But generally, and especially in the graywacke formation, the strata dip more or less beneath the horizon, and of course the coal beds will dip at the same angle. Being thus inclined, they will also run in the same direction as the upturned edges of the rock in which they are contained. Hence every coal bed will have a certain dip and direction. The extent to which the bed on the Harden farm in Mansfield has been opened, viz. 150 feet each way from the shaft, affords a good opportunity to determine these points in respect to that mine. I applied the clinometer and pocket compass at the bottom of this mine, and found the dip to be 53° north-westerly, and the direction nearly N. E. and S. W., though exhibiting minor deviations. And such are the dip and direction, within a few degrees, of all the rocks and coal beds that have been explored in the graywacke of Bristol county and in Rhode Island; except that on the Island it is said the dip is 90° south-easterly.

The preceding facts will enable us to judge respecting the situation of the coal beds in this great coal field; and perhaps show us what is the best method of research to ascertain how many beds actually exist, and also how they may be most advantageously worked. The following sketch may assist in understanding the subject. It is a supposed vertical section of the soil and rocks beneath the plain of Mansfield. It runs N. W. and S. E. so as to cross the strata of rocks at right angles. Twenty feet of diluvial soil are represented as covering the rocks, and they are shown dipping between 50° and 60° to the north-west. Several beds of coal, *a*, *a*, *a*, *a*, *a*, are shown lying between the strata.



Now it is evident, that if a trench could be cut through the loose soil across the edges of the strata, it would bring into view all the beds of coal that exist in them. But several gentlemen, who are practically acquainted with such operations, assure me, that such a trench would be far more expensive than it would be to sink a shaft several hundred feet into the rock, as shown above at A; and then to push horizontal drifts through the rocks at right angles to the strata, as is represented above by B, B, which crosses the coal beds *a*, *a*, *a*, *a*, *a*. And besides, were this done, and a rail-way laid at the bottom of the drift, as soon as a bed of coal was discovered, the mining and raising of it might immediately commence, without preventing the further prosecution of the drift.

This, then, appears to me, the thing that is wanted in the region under consideration. Suppose such a shaft, for instance, to be sunk 300 or 400 feet in the vicinity of the mine on the Harden farm, and a drift extended in opposite directions across the strata. We might be almost certain that these drifts would cross several valuable beds, since they are known already to exist in the vicinity. And thus the proprietors might have a fair prospect of remuneration, even if no new beds should be discovered: since this would probably, in the end, be the most economical way of opening the beds now known. But it is hardly to be conceived that no new and valuable beds would be discovered by extending the drift farther. Yet if they should not be found after carrying it forward a reasonable distance, it might be abandoned with little loss. How far it might be thought advisable to prosecute such a drift, it is difficult to say, until the work be begun: but perhaps it would be desirable to extend it several miles; which might be done, I understand, for less than $25,000 per mile, exclusive of the cost of the shaft. I should not be surprised if in tunneling towards the north-west, from the centre of Mansfield, at the depth of 300 or 400 feet, the level should, ere many miles, be arrested by unstratified rocks, which rise to the surface within a few miles in that direction, and the greywacke may be thinner near the edges of the formation than in its more central parts. In the opposite direction, I should not expect any such obstruction, till the drift had been carried to the eastern part of Middleborough.

While writing the preceding paragraphs I was gratified to learn, that the three companies above named, as engaged in mining for coal in Mansfield, are about to unite their resources for examining the vicinity of that place, by a plan essentially the same as that mentioned above. At a season of such general stagnation of enterprise and business, this resolution is certainly deserving of high commendation. For should these companies succeed in laying open a sufficient number of beds of coal to supply the wants of the eastern half of Massachusetts, (and I am not without strong hopes that they may succeed,) so as to render our citizens independent of foreign importation, and reduce the price of fuel at least one half, hardly anything can be thought of that would give such a spur to industry and enterprise, and tend more to permanent prosperity. And allow me to inquire, whether the object is not of sufficient importance, and the prospect of success encouraging enough, to induce the Government of the State, by loan or otherwise, to encourage this undertaking. In general, it is probably best, to leave such enterprises to private efforts ; but in this case the investments must be so heavy that private companies may not feel justified in appropriating sufficient money to have the work done thoroughly : and if the Government, probably without any pecuniary loss, can lend its aid, it will give a powerful stimulus to private exertions. I make this suggestion, however, without any request on the part of these companies, and even with scarcely a personal acquaintance with any of their number.

Diluvial Drift of Coal.

General Chandler mentioned to me a mode of exploring for coal, which he had successfully adopted, and which may be of use to others, depending on a knowledge of the direction which was taken by the diluvial waters that deposited the deep accumulation of sand and gravel lying over the coal region. It is an ingenious practical application, and at the same time a beautiful illustration and confirmation of the general doctrine advanced in my former Report, that a powerful diluvial current has swept over this state from the north. Whenever in digging into the soil he found fragments of coal, guided by this principle, he dug in a northerly direction ; and never failed to find the number and size of the fragments to increase until he arrived at the bed from which they were broken. Following the fragments in the opposite direction, they continued to decrease in size and number until at the distance of several rods from the bed they disappeared. Hence, if in digging through the soil no fragments of coal should occur, it might pretty safely be inferred that no bed of much size exists for several rods in a northerly direction; and if they are found, the explorer need be at no loss in what direction he will find the bed.

Coal Bed in Foxborough.

I ought perhaps to have described the coal bed in Foxborough earlier. For it is only about two miles from the excavations in Mansfield, and belongs to the same coal field. Good coal was obtained there, formerly, in two places a few rods apart: but the shafts are now filled up. A specimen of this coal gave the following results upon analysis:

Water,	5
Carbon,	77
Earths, oxides, &c.,	18
	100

Specific gravity, 1.86.

The quantity of earthy matter here is much larger than in the specimens from Mansfield; yet it is not much larger than some of the coals contain that are extensively used; and very probably the specimen which I analysed was comparatively poor. It is not probable, however, that this bed will be re-opened at present.

Coal Bed in Cumberland, Rhode Island.

The coal bed in Cumberland, Rhode Island, ought also to be noticed in this connection. For although several miles distant from Mansfield, yet it lies in the same rock formation, and only a mile or two beyond the limits of Massachusetts. This has been wrought by the New England Coal Mining Company to the depth of 70 feet: but operations are now suspended in consequence of the destruction of the works by fire. At the out crop, beneath 20 feet of diluvium, its width was 9 feet; but at 40 feet in depth, it had increased to 14 feet. The dip and direction of the bed correspond essentially with those in Mansfield. For these facts I am indebted to Mr. Foster Bryant, who says also, that there was a decided increase in the value of the coal as it was taken from successively greater depths. I did not obtain any specimens for analysis from this mine; and I confess, that when I visited it, I was not so favorably impressed with appearances there as at the mines in Mansfield. I saw among the fragments thrown out, scarcely any impressions of vegetables, and much of the rock exhibited a glazed plumbaginous appearance, as well as a more crystalline arrangement of parts, than is usually found in connection with good coal. This I suppose to result from the greater nearness of this spot to the unstratified rocks, than the mines at Mansfield. These rocks have doubtless once been melted; and they have probably heated the coal beds so much in some places, as to obliterate the organic remains and convert the coal almost, and in some cases quite, into plumbago. Hence I should expect that the coal from such spots would be more difficult of combustion, and often contain more ashes. I noticed the same appearances to some extent at Foxborough, and still more strikingly at the coal bed in Wrentham, and both these places are quite in proximity with unstratified sienite or granite. Mr. Bryant, however, thinks the Cumberland coal as good as that in Mansfield; and both of them nearly equal to that from Pennsylvania. And I may be mistaken in these suggestions; but I thought it might be well to mention the insalutary influence of unstratified rocks upon coal, that explorers might be put upon their guard.

Several other excavations in search of coal have been made in Mansfield and its vicinity; but as they are not large, and little success has attended the efforts, I do not think it necessary to go into details respecting them; although I visited all of which I could obtain any knowledge.

The beautiful impressions of vegetables found upon the slate that embraces the coal at Mansfield, are deeply interesting in a scientific point of view, and will receive due attention in the proper place. But I do not think proper to attempt a description of them at this time.

The Worcester Coal.

No attempt has been made since my former Report to resume operations at the Worcester coal bed, although such I believe has been the intention of the proprietor. This coal being in a decidedly older class of rocks than those at Mansfield, is of course more mineralized, and will burn with more difficulty. Yet it is certain, that it is used to advantage in some manufacturing establishments, if not in private families, and hence it may be of great importance. I have nothing new to add respecting it, however, except an analysis of an ordinary specimen, probably not the best, that happened to be in my possession.

Water, ...	3
Carbon, ...	75
Earths and oxides, ...	20
	100

Specific gravity, 2.12

By looking at the Geological Map of the State, it will be seen that the rock formation which embraces the Worcester coal, extends to the mouth of Merrimack river; and of course, coal may be found in other parts of the formation besides Worcester. In Bradford, where the general aspect of the country, the character of the soil and of the rocks, correspond almost exactly to the region around Worcester, an exploration is going on for coal by means of boring, which has been continued to the depth of nearly one hundred feet. I saw, however, no peculiar encouragement at this place, more than at almost any other in the town. Should coal be found there, it will undoubtedly be of the same character as that in Worcester.

Bituminous Coal, West Springfield.

In my former Report (p. 232, 2d edition) a locality of bituminous coal is described on the north bank of Agawam river in West Springfield, where there is a remarkable upward bend in the sandstone rocks; the arch having a span, however, of only a few rods. Within two years past, the banks and bed of the river at this place have been somewhat extensively excavated for building factories. The consequence was, the bringing to light of coal in larger quantity, and of the most beautiful variety, that I have ever seen. (No. 206.) It appears to exist here in the form of small and irregular veins, the coal also being filled with numerous thin veins and crystallizations of calcareous spar. This is a most remarkable mode of occurrence, and very interesting in a scientific point of view: and perhaps, also, of consequence in a practical point of view: otherwise I should not here describe it. Coal is, indeed, described in geological books as sometimes occupying fissures in rocks, along with fragments of those rocks: but in this case the coal is broken by mechanical violence. Yet at West Springfield, it has evidently been filled into the fissures, just as the associated calcareous spar was, by a chemical agency. The latter may have been deposited from water: but I can conceive of no way in which the coal could have been formed, but by sublimation and subsequent solidification, as the temperature was reduced. In short, my supposition is, that coal may exist beneath this spot, and that by the agency of trap rocks, a part of it was melted, the superincumbent sandstone forced up, and into its fractures the melted and sublimated coal ascending, but not being able to escape, was reconsolidated into coal. I am not aware of any analogous fact having been noticed elsewhere; and this makes me less confident in this hypothesis. Yet every fact respecting this coal corresponds to it, as does also its chemical composition. For if it were the result of sublimation, we might expect it to be free from those earthy and metallic matters, that I believe have always been found in coal upon analysis. And such, it will be seen, is the fact with the West Springfield coal: or rather it is free from impurity as most crystals are. It is, indeed, difficult to separate mechanically from this coal all the thin layers of calcareous spar with which it abounds, and hence there will often be a small residuum after burning in a platinum bowl: but diluted cold nitric acid dissolved this almost entirely, with effervescence in three trials which I made; and hence I conclude it to be carbonate of lime, which ought not to be reckoned as an impurity, because existing only in the fissures of the coal.

A pure specimen of this coal yielded, upon analysis, as follows:

Volatile matter, (water and bitumen,) -	22.00
Carbon, - - - -	77.97
Earthy residuum, - - -	0.03
	100.

The method which I adopted to ascertain the amount of volatile matter, was simply to heat the triturated coal in a broad platinum bowl, nearly to redness, until all the bituminous odor had disappeared. This, I am aware, is not a very satisfactory mode of determining the amount of bitumen; but it is sufficient for my present purpose to show, that a rather large proportion of bitumen exists in this coal. And every one must see, that its composition is such as would make it one of the finest coals ever discovered, could it be found in sufficient quantity.

If the hypothesis above advanced be true, there would result as an inference a probability, that, by boring into the sandstone in the bed of the river at the highest part of the arch, a bed of coal might be discovered. And since the span of that arch is so limited, it seems hardly possible, that the upheaving power can be situated more than 100 or 200 feet below the river: that is, the trap rock, the supposed disturbing cause, would probably be struck before that depth were reached; and since the coal, if it exist, must lie above the trap rock, this also would be reached. Whether the probability of finding a bed of workable coal is strong enough to justify the expenditure of a few hundred dollars in such an exploration, others concerned can now judge as well as myself.

The spot where this coal occurs, it may be well to mention, lies directly on the route of the rail-road from Springfield to Albany.

Peat.

Taking the state as a whole, peat is but little used, either as fuel or manure; though most employed for the latter purpose. Yet for both purposes its use is rapidly increasing, especially in the eastern part of the state, where fuel is more expensive. In view of its importance, I have made some efforts to ascertain its probable amount in our swamps. But this is very difficult; both because our swamps, where it occurs, have been but slightly explored, and because much is called merely mud, that deserves the name of peat. Several gentlemen, however, to whom I addressed inquiries on this subject, in different towns, have ventured to give an opinion as to the thickness of the beds, and the number of acres of peat found there. The following statement embraces nearly 50 towns; though by no means all in which I know peat to exist. But my object at this time is to give data for forming an approximate estimate of the amount of this deposite in the state. Several other localities will be found in my ormer Report.

TOWNS.	Thickness of the Beds.	Acres covered by Peat Swamps.	Use.	Authority.
Andover,	1 to 8 feet.	More than 2000.	Fuel and manure.	Alonzo Gray.
Athol,	2 to 3 feet.	Swamp 2 miles long, 80 rods wide, (300)	Scarcely used.	Alden Spooner.
Abington,	Abundant.			Thom. H. Perry.
Amesbury,	10 feet, sometimes.	100 acres at least.	Little used.	Patten Sargent.
Barnstable,	15 feet, sometimes.	200 acres.	For fuel only.	
Buckland,	1 swamp 30 ft. deep of mud.	50 acres swamp.		Silas Smith.
Bellingham,	3 to 8 feet.	"Probably 5 or 6 acres."		John Cook, 2d.
Bernardston,		30 to 40 acres, much peat.	Manure only.	H. W Cushman.
Bridgewater,	Extensive beds.		Fuel and manure.	P. Leach.
Concord,	2 to 8 feet.	500 to 700 acres.	do do	Cyrus Stow.
Carver,	8 to 10 ft. of mud in swamps.	500 to 800 acres bog swamps.	Not used.	John Savery.
Chilmark,	Various.	Perhaps 100 acres.		
Dennis,	1 to 4 feet.	100 to 200 acres.	Fuel.	L. Nickerson.
Dighton,	Plenty.		Not much used.	
Duxbury,	2 to 20 feet and more.	Abundant.	Fuel and manure.	Gershom Bradford.
Eastham,	2 feet to unknown depth.	do		George Collins.
Falmouth,	10 to 15 feet.	20 to 30 acres.	Manure.	Wm. Parker.
Groton,	5 to 20 feet.	Hundreds of acres.	Manure chiefly.	J. Green.
Hingham,	2 to 6 feet.	50 to 100 acres.		Henry Cushing.
Halifax,	2 to 10 feet.	100 to 200 acres.	Beginning to be used	J. P. Thompson.
Hanson,	1 to 10 feet.	1000 acres.	Fuel and manure.	F. P. Howland.
Hanover,	Rather abundant.		Lately used.	A. G Duncan.
Holden,	Not abundant.		Manure only.	John Chaffin.
Kingston,	2 to 10 feet.	Many swamps.	Manure.	Asaph Holmes.
Lunenburg,	Inexhaustible.	100 acres.	Not used.	
Longmeadow,		Perhaps 10 acres.		
Ludlow,	12 to 15 feet.	50 acres.	Manure.	H. W. B. Alden.
Lynnfield,	10 to 12 feet, sometimes.	100 to 200 acres.		William Perkins.
Methuen,	3 to 6 feet.	More than 50 acres.	Fuel.	Stephen Parker.

TOWNS.	Thickness of the Beds.	Acres covered by Peat Swamps.	Use.	Authority.
Millbury,	3 to 10 feet.	Extensive beds.	Fuel.	Asa H. Waters.
Natick,	3 to 6 feet.	500 acres tested, 300 to 400 more.	do	Chester Adams.
Oxford,	4 to 12 feet.	Several hundreds.		Stephen Davis.
Nantucket,	1 to 14 feet.	985 acres.		Jared Coffin.
Randolph,	1 foot to a great depth.		Fuel chiefly.	Zenas French, Jr.
Rowley,	3 to 6 feet.	More than 500 acres.		
Roxbury,	30 inches average.		Manure chiefly.	A. A. Hayes.
Spencer,	2 to 30 feet.	1000 to 2000 acres.	Fuel this year.	Jonas Guilford.
Southborough,	Thick.	500 acres.	Fuel and manure.	Joel Burnet.
South Reading,	3 feet average.	200 acres.		Lilley Eaton.
Weston,	10 feet and less.	Numerous swamps.	Manure.	A. Bigelow, Jr.
Wales & Holl'd,	4 to 10 feet.	200 acres.	do	E. G. Fuller.
Wilmington,	"Two cuttings deep."	"Some hundreds."	Fuel.	Silas Brown.
Westford,	Abundant.			Julian Abbot.

It will be seen, that scarcely any towns, in the four western counties of the state, are mentioned above. This is partly explained by the fact, that fuel is more plenty there than in the eastern counties, so that public attention has never been directed so much to our fossil resources. But I think it undeniable, that the amount of good peat in the western counties is much less than in the eastern. Although perhaps the swamps abound as much in vegetable matter, that would be useful in agriculture, yet it does not seem to be converted into genuine peat, though I doubt not that it will be easy to find a large amount of it when there is a demand for it. Excluding these western counties, and taking the amount of peat given in the above statement as a fair average of its quantity in all the towns of the other counties, (excluding the large towns,) it would follow, that 80,000 acres, or 125 square miles, are covered with peat in that portion of the state, being an average thickness of 6 feet 4 inches. This area and depth would yield not far from 121 millions of cords. If this should be thought by any to exceed the quantity of good peat existing in that section, I presume no one will consider it too high an estimate of the amount of swamps filled with vegetable matter. I presume it falls far short of the true amount. And we hence get an enlarged view of the quantity of matter in the state that may be employed as fuel, or in agriculture, that has hitherto, except in some limited districts, remained almost untouched. It is true, that peat is not so convenient and agreeable a kind of fuel as good wood or coal; yet it certainly answers a very good purpose, and the facts in the case tend to allay the apprehension, which must sometimes rise in the mind of one who sees, in the gradual diminution of our forests, a future check to our prosperity and population. It is gratifying to learn, from so many towns, that the inhabitants are awaking so much to the use of peat and peaty matter. Some gentlemen have even spoken of it as a "peat fever." I hope it has not yet reached its crisis.

13. METALLIC ORES.

To this department of our mineral resources I have found time, during the year, to give but a very inadequate attention. Some new localities, however, have come to my knowledge, and the results of all that I know of them will now be given.

Carbonate of Iron in Newbury.

As one passes from Newburyport to Kent's Island in Newbury, just as he arrives at the northern margin of the salt marsh surrounding the island, he will notice abundant fragments of a white rock, coated over with iron rust. Suspecting it to be carbonate of iron, I collected specimens (No. 176) and have subjected one to analysis with the following results:

Carbonate of lime, - - - -	45.67
Carbonate of magnesia, - - - - -	8.97
Proto-carbonate of iron, - - -	21.76
Proto-carbonate of manganese, - -	16.10
Silica and alumina, - - - -	3.34
Loss, - - - - - -	4.16
	100.

Specific gravity, 2.94.

The small quantity of iron in the specimen above analysed, and the abundance of lime and magnesia, leaves one in doubt whether it ought not to be regarded rather as a magnesian limestone, containing a large amount of iron and manganese. A more important question is, whether, with so little iron, this mineral can be profitably wrought. And yet some of the ores of spathic iron in Europe that are smelted, contain only a little more than 20 per cent of the carbonate of iron. This ore is regarded in Europe as one of the most valuable of all the ores of iron, especially for the manufacture of steel; the well known German steel being obtained from it: and the character of most of the substances mixed with it in Newbury, especially of the lime, will probably render any other flux unnecessary in working it, unless it be clay. At any rate, as I noticed the quantity of the mineral to be very great at the spot above named, and as I may not have selected the richest specimens to be found there, I have thought it would be best to call the attention of the Government to the locality.

Magnetic Iron in Warwick.

It was not till too late in the autumn to visit the spot, that my attention was called to a locality of magnetic iron in Warwick, which, from the description given me, is probably the most extensive in the State. Yet I am told that an attempt to work it some years ago was abandoned, on account of some supposed impurity. I felt, therefore, desirous to determine its composition, and having obtained a specimen (No. 177) through the kindness of Alden Spooner, Esq., I made a single analysis with the following results:

Protoxide and peroxide of iron, - -	66.4
Oxide of manganese, - - - - -	16.6
Silica and alumina, - - - - -	17.0
	100.

Specific gravity, 4.47.

The large quantity of manganese in this ore and its great compactness of structure, are probably the cause of the difficulties that were met in attempting to work it. Probably they might be overcome by the use of anthracite coal in a blast furnace, or still more effectually, by the use of the hot air blast, which is coming extensively into use in our country: since probably all that is wanted is an increase of heat. Some other substance besides manganese, whose presence is injurious, may have escaped my notice in the analysis, especially as I have not found time to confirm it by repetition. But an extensive bed of good iron ore ought not to be abandoned without very thorough trial: and if what I have here given shall call the attention of gentlemen, who are interested in the reduction of iron ore, to this deposite, my object will be accomplished.

Chromite of Iron.

In the second edition of my former Report, (p. 366,) I called the attention of the Government to several deposites of this uncommon and valuable ore, especially to one brought to light in Chester by Dr. H. Holland. That gentleman has recently furnished me with additional information respecting the extent and composition of this ore, which I will state in his own language.

"The chrome ore," he says, "appears only in the eastern portion of the serpentine. I have found three distinct 'out-cropping' veins of the ore, or more properly *couches*, crossing the serpentine which is schistose and deep green, east and west, from 5 to 18 inches in width. I had a man blast one of the couches, and with a few hours' labor procured some 1200 pounds of the ore. I have one mass very pure of 60 pounds."

"I have tested the mineral as accurately as possible to determine its comparative value, and found it upon analysis, similar to Uralian chromite of iron, giving from 52 to 53 per cent of oxide of chrome, as it enters into composition, a protoxide. The iron is from 33 to 35 per cent, a peroxide, by calcination: which removed by hydrochloric acid, from the residuum of first calcination, *gave a distinct trace of platinum, as I considered it.*"

"Perhaps I might have been mistaken. I was led to notice it, from the fact that platinum is found associated with chromite of iron in Siberia as well as in the chromite of iron and iron sand of St. Domingo. The Chester chromite of iron has been tested by the Messrs. Tieman of New York, practical chemists. When made fine and freed from the matrix, silex, alumina and magnesia, as pure as usual for the arts in gross, it is found to yield, like the Maryland and Pennsylvania chrome ore, about 43 per cent of protoxide of chrome, which combines with the potash."

It is well known that some of the most beautiful paints in use, as the chrome yellow, chrome green, &c. are prepared from this ore. And to such a use it is Dr. Holland's intention to apply the Chester chromite, whenever it can be done profitably. The foreign salts of chrome have till recently been sold at so low a rate, that it has been impossible to compete with them in a country where labor is so dear as among us. But these articles have recently risen in market: and it seems hardly possible to doubt, but that a mine of chromite of iron must ere many years become exceedingly valuable. A few years since, Dr. Holland prepared several salts from the Chester chromite, and he has been kind enough to send me the only parcels of them yet remaining, and I have put them into the collection forwarded herewith. No. 220 is a specimen of the Chester chromate of iron: No. 221 chromate of potassa: No. 222 chromate of lead, or chrome yellow: No. 223 dichromate of lead.

Hematite Iron Ore. (Limonite.)

I formerly supposed that the rich beds of this ore in Berkshire were contained in a tertiary formation; but an examination of many other beds in New York, has satisfied me, that the beds, which at their upper part are mixed with clay and soil, extend downwards, into the older rocks, the mica slate and talcose slate of Berkshire county. Indeed, at West Stockbridge, (the only bed in Berkshire that I have recently examined,) the excavation has proceeded so far as to bring to view the ore that has never been disturbed, having the same inclination as the rocks of that region; while we see that all the upper portion has been broken up and mixed together by diluvial and alluvial action. This appears to me to be an interesting and important fact. For had this ore extended no deeper than the loose soil, it would ere long have been exhausted. But if it forms beds in the rocks beneath, there is little danger that the bottom of it will ever be reached.

I am informed by E. B. Garfield, Esq., that several hundred tons of the Limonite have been dug in the south part of Tyringham, and that "strong indications of extensive beds" exist there. And I have already alluded to the probable existence of an extensive bed in the west part of New Marlborough. I mention these facts, because no notice was taken of them in my former reports, and because they add another item to the rich list of mineral resources in Berkshire county.

Copperas (Sulphate of Iron) from the Sulphuret of Iron.

I am informed by Ethan A. Greenwood, Esq., that at the copperas works in Hubbardston, not less than 75 tons of that salt, of good quality, are annually manufactured, and that the quantity of ore is inexhaustible; a fact of which any one I think will be convinced, who will visit the locality. I see not why these works may not be carried on profitably to a very great extent.

Galena in Uxbridge.

A vein, or more probably a bed, of the sulphuret of lead, exists on the farm of Chilon Tucker in the south-west part of Uxbridge. It is in quartz rock and has been excavated a few feet. But the indications are certainly not very encouraging. Facts of this description, however, should be recorded, as they often lead to valuable discoveries.

Blende, Galena and Copper Ore in Russell.

John Gould, Esq., has sent me from his farm in Russell, specimens of quartz containing sulphuret of zinc, sulphuret of lead, and a small quantity of sulphuret of copper. The ore with its gangue exactly resembles that at the Southampton mines, and I doubt not but there exists in Russell another vein similar to those in Southampton, Hatfield, Williamsburgh, &c., which I have formerly described. I have learned nothing of the extent of the supposed vein in Russell.

Galena, Blende, and Titanium, in Norwich.

A similar vein of ore has been discovered in Norwich, and has been wrought to some extent by the proprietor, Mr. Quartus Angell, who has sent me specimens, and says, that the vein is about three feet wide. The ore, which I consider as titanium without chemical analysis, appears in these specimens to be more abundant than the others. A variety of porcelain clay occurs at the same place, which I shall notice farther on.

Galena in West Stockbridge and Alford.

Charles B. Boynton, Esq., of West Stockbridge, informs me, that galena occurs in the south part of that town; and I am told also by Roswell Picket, Esq., that the same ore is found a mile north of the centre of Alford. It is possible that the two localities, being so near each other, may have been confounded; but more probable that the same vein extends into the two towns. I know nothing of the appearance of the ore in the rocks.

With the exception of that in Uxbridge, I have not been able to visit any of the above mentioned localities of lead, zinc, and copper ore, chiefly because they were in most instances not made known to me till too late in the season. Their existence, however, should be recorded, and the requisite examinations can be made at a future time.*

14. OCHRES AND STONE PAINTS.

It is well known, that the oxide of iron, mixed with clay or soil, forms the paints called ochres. Although very many places in our soils have an ochrey appearance, yet I have not till recently met with any deposites in Massachusetts that appeared to me to promise much for paints. Those of which specimens will now be found in the collection herewith sent, seem to me worthy the attention of those who prepare colors.

The deposite which promises far more than any other that I have seen, accidentally arrested my attention, as I was passing the farm of Josiah Sheldon in the west part of New Marlborough. In several places over a hill embracing a number of acres, he has made excavations a few feet deep, and found an abundance of yellow and light red ochres, (see Nos. 164, 165) which probably might yield some of the best of this sort of paints. And besides, it seems very probable, that there will be found in this field a rich bed of the hydrate of iron, or the hematitic iron ore, so abundant in other parts of Berkshire county.

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* Mr. Thomas H. Perry, of Abington, informs me, that not long since several ounces of quicksilver were washed out from a bushel or two of sand on the margin of a pond on land of Benjamin Hobart, Esq. That gentleman has shown me a specimen, and says, that the sand in which it was found had been previously carted from an excavation of considerable depth in the vicinity. He says that the spot is quite an unfrequented one, and that he can conceive no way in which the quicksilver could have been accidentally spilled there. He has not, however, examined the excavation to ascertain whether more may not be found. It would be premature therefore, to decide that this is actually a locality of native quicksilver; but the fact would be so interesting should it prove to be so, that I give this note in order to excite to further examination. Near the same spot, Mr. Hobart informs me an excavation a few feet deep has been made in search of coal in the graywacke, and some impure specimens obtained, and preparations are making for further explorations.

No. 163 was obtained from what is called the Jewett farm, in the north part of Rowley, on the road to Newbury. It occurs in a low spot of ground, and has been formerly used for painting a house. The specimen is of a coarser texture than those from New Marlborough: but the former excavation was nearly filled up, and I had no time to have it re-opened; so that, perhaps, this specimen does not exhibit a fair sample of this locality.

No. 161 was sent me from Athol, by Alden Spooner, Esq., who says that it occurs in the north part of the town, and also in Templeton; but he gives no farther particulars.

No. 162 is from Monroe, for which I am indebted to Martin Ballou, Esq. He informs me, that it was formerly dug to some extent and prepared for paint; but not being in much demand, the work was abandoned. It certainly appears as if it might be valuable.

While this report was in press, I received from Bedford a specimen of yellow ochre of very good quality; but too late to be added at present to the state collection. I am informed that it occurs there "in two or more places," and in considerable quantity.

In my former Report, I suggested the use of the sulphate of baryta, which occurs in great quantity in Hatfield, as a paint—a patent having been taken out for its preparation. But I am not aware that the Hatfield stone has been employed for this purpose. Other rocks, also, which have of late been used as lithic paints, abound in this state. Soapstone, of which we have such inexhaustible quantities, is considered best for this purpose, and serpentine is also employed. These are ground with whale oil; and in Connecticut, where they have been manufactured, they are sold for five dollars per hundred pounds. They answer a good purpose as a basis for common paints, especially for the roofs of houses. I should presume that the newly discovered serpentine in Lynnfield is very well adapted for this object, being unusually soft and free from foreign minerals.

15. Moulding Sand.

I have been surprised to find, on inquiry of gentlemen in various parts of the state, who are engaged in casting iron and brass, that nearly all their moulding sand is brought from beyond the limits of the state; and most of it from as great a distance at least, as Hudson river. I feel a strong confidence that this need not be always thus; and that careful research may bring to light good moulding sand within our own limits. Captain Lemuel Drake, of Easton, who has the management of extensive castings in iron, informs me, that he has obtained moulding sand, though not of the best quality, in Bridgewater, Medfield, Easton, and Foxborough. No. 166 is a specimen from the last named place, and No. 167 is from Montague; which I have placed in the Collection because it bears a resemblance to good moulding sand, although it has not been thoroughly tried. For a similar reason I have put up No. 168, from Norwich. It appears to be the result of the decomposition of granite, and may perhaps answer in the casting of brass. I have one or two other specimens, which I mean as soon as possible to submit to the examination and trial of men practically acquainted with the subject.

A. A. Hayes, Esq., of Roxbury, informs me, that a variety of quicksand is sometimes employed there by the brass founders, and that it makes a sharp impression. The same substance is used in Carver, as I am told, by John Savery, Esq., for parting the moulds of castings, and for the case of tea-kettle spouts.

My statements on this subject are so immature and meagre, that I should not give them, did I not hope thereby to excite observing men to notice substances that might be employed for moulding sand, which may fall in their way.

16. PORCELAIN AND PIPE CLAY.

Kowing how important in several manufactures is white clay which contains no iron, and how rare it is in New England, I have sought after it with care. It has long been known that such a clay exists at Gay Head, and in other places on Martha's Vineyard; and it has been used for several purposes: yet it is not delicate enough for the manufacturer of porcelain, though valuable for coarser articles. During the past winter, specimens have been sent me from the vicinity of the lead and zinc ore in Norwich, noticed above, which appear to be a variety of porcelain clay; and so far as I can judge from the imperfect description that has been furnished me, it appears to be abundant. Some of this, along with a specimen from Gay Head, I have subjected to analysis in the usual way, and obtained the following results:

	Gay Head Clay.	*Norwich Clay.*
Water of Absorption,	9.00	8.00
Silica,	62.26	53.40
Alumina,	29.31	36.26
Lime,	0.18	0.24
Magnesia,	0.45	0.68
Manganese,	0.15	0.20
Loss,		1.22
	101.35	100.

No iron could be detected in the above specimens; (Nos. 144 and 145 of the Collection.) And since clay of this description is so important for the manufacture of fine bricks, white pottery, and porcelain, it will be an object to have farther examinations made of the Norwich bed. Its composition corresponds very well with that of many of the European porcelain clays, although I believe in them no manganese has been detected. But the minute quantity found by me cannot affect the value of the clay. Some of this clay is quite hard.

It is by no means all of our white clays that are destitute of iron, as may be seen by examing Nos. 142 and 143. And it may be well to mention an easy method of determining, when chemical tests are not at hand, whether a clay contain iron or not. If it does not it will not turn yellow or red when burnt strongly in the fire. The red color of our common bricks is occasioned by the iron which they contain, and which is peroxidised by the heat.

17. Clay as a substitute for Fuller's Earth.

In my former Report I mentioned the fact, that the common clay of the Connecticut valley had been used as a substitute for Fuller's Earth. But I was not till recently aware how extensively this substitution had been made. I am told by the Agent of the Woollen Factory in Northampton, that this substitution is made very extensively in this state and in Connecticut, and that the clay is considered even better than the Fuller's Earth for cleansing the dye-stuff from cloth. That in Northampton has been considered as rather better than in other places; and hence it is transported often quite a distance. It is also used in private families for extracting grease and oil from cloth. It is first made into a paste, and then applied and suffered to dry. It doubtless operates by its great absorbing power. When applied to the tongue it adheres very firmly. No. 183 is a specimen from Northampton.

I learn that the clay in the north part of Worcester County is employed in the same manner; and I doubt not but the variety proper for this use may be found in many parts of the state; although that in the valley of the Connecticut appears to be rather better than any that I have met with elsewhere. Fullers' earth, which is brought from England, sells, I am told, for $10 per ton. The clay can cost nothing but the transportation.

18. Feldspar and Albite for the glazing of Porcelain Ware.

The articles of pottery and porcelain made from white clay need to be covered with a glaze of some other substance: that is, with an enamel, or glass: for the clay in its pure state does not melt in common furnaces. Now feldspar and albite, whose composition is very much alike, except that the latter contains soda and the former potassa, on account of the alkalies in their composition, may be melted in a strong heat: and hence they are employed for the most delicate kinds of glazing. Common glazing, which consists of powdered gun flints, litharge and table salt, is so soft as soon to yield to the mechanical and chemical agents to which the articles are exposed; and it would be very desirable that feldspar might be employed in all cases, though, as the process for its preparation is at present conducted, it would be more expensive.

I know of no attempt to employ any of the feldspar of Massachusetts for glazing; and yet we possess in our granites, sienites, and gneiss, inexhaustible quantities, and much, no doubt, pure enough for this purpose. Can there be any doubt, for instance, but that the adularia of Brimfield, Southbridge, &c. would furnish a most admirable article, since it is nothing but the very purest variety of feldspar. The best locality of albite in the state is in the north-west part of Chesterfield, on the farm of Mr. Clark: and I have understood that it has been purchased not long since, by a company in New York, for the purpose of using it in the manufacture of China ware, or porcelain: but I have not learned whether they are now prosecuting the work.

Beds of feldspar and albite have been quarried in Connecticut, within a few years past, with much success. In Middletown alone, in the year 1836, seven hundred tons were dug out; six hundred of which were shipped to Liverpool.*

19. FELDSPAR AND MICA FOR OBTAINING POTASSA.

Good feldspar contains nearly 20 per cent, and mica 16 per cent, of potassa; and it has recently been proposed in Europe to extract the alkali by calcination with lime. While our forests remain so extensive as at present, we shall not need to resort to this method to obtain potassa. But should coal ever become the principal fuel, it is gratifying to know that we have so abundant a source of this valuable substance. Albite, treated in like manner, would yield soda, though only about 9 or 10 per cent.

20. MATERIALS FOR WATER-PROOF CEMENT.

I have already expressed the opinion that the best materials in the state for making a mortar that will harden under water, and which goes by the name of Water Cement, Hydraulic Cement, Roman Cement, &c., had not yet been used. I presumed that the argillo-ferruginous limestone, of Springfield and West Springfield, (No. 185,) much of which occurs in nodules, which are now thrown away, is much better adapted to this purpose than the fetid limestone in use. I am confirmed in this opinion by the following remarks, which I have translated from a recent work by Professor Mitscherlich, of Berlin, than whom no better authority could be quoted. He says, "the best hydraulic lime is obtained from an argillo-calcareous rock, which is found in concretionary masses in marl; (the West Springfield rock, would in Europe, probably, be called *red marle.*) If this be reduced into a thick paste by water, it becomes solid as rapidly as gypsum: its solidity increases with the time during which it is immersed, (in water,) and it finally acquires the hardness of limestone."* I felt some little doubt what might be the effect of the magnesia which analysis shows this rock to contain. But Mitscherlich says, that "according to experiments in the small way, magnesian limestone merits the preference over the carbonate of lime." So that I very much hope that some of our enterprising citizens will make a trial of this limestone—tons of which can easily be obtained where excavations are going on in the Springfields.

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* Prof. Shephard's Geological Report, p. 72.

Another substance mentioned by this writer as valuable for water-proof mortar, deserves to be noticed, especially as it may be of service to the inhabitants of Berkshire, where the common hydraulic limestone does not occur. "A marl," says Mitscherlich, "which contains from 13 to 19 per cent of clay, makes a good hydraulic mortar; and if the clay contains an excess of silica, this circumstance increases the good qualities of the mortar." He refers, I presume, to indurated marl: but I know of no reason why that which is pulverulent may not answer equally well, after being burnt into quicklime.

Another mode of preparing the water-proof mortar, is by mixing certain substances with lime in particular proportions. *Puzzolana,* which is a substance ejected in former times from volcanoes—a kind of volcanic ashes—is one of the ingredients that has been employed from the earliest times. *Trass* or *Tarras,* is a vesicular decomposing basalt, which has been extensively employed for the same purpose in Holland, in the construction of dykes against the sea. I am satisfied that the vesicular decomposing amygdaloid, so common in the region of Connecticut river, is so very similar to tarras and puzzolana, that it might profitably be employed for the same purpose. I have accordingly subjected a specimen to analysis, (No. 160,) taken from Mount Holyoke, in the north-east part of Belchertown, where great quantities of it may be obtained. The following are the results.

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* Elémens de Chimie, par E. Mitscherlich, Professor de Chimie a Berlin, &c.; tome Troisieme, p. 120. Bruxelles, 1836.

Water,	8.50
Silica,	53.70
Alumina,	13.00
Peroxide of Iron,	21.00
Oxide of manganese,	0.19
Lime,	0.70
Magnesia,	0.15
Sulpher, and loss,	2.76
	100.

By an analysis of Bergmann, puzzolana has the following compotion :

Silica,	55	to	60	per cent.
Alumina,	19	"	20	"
Calcareous matter,	5	"	6	"
Iron,	15	"	20	"

The correspondence between this analysis and the one which I have given, is near enough to show that in all probability both would answer almost equally well for the water cement. And I strongly hope that this substance, for which there is such an increasing demand, will not much longer be imported from Europe.

21. STEATITE OR SOAPSTONE.

Waving all remarks respecting the strictly scientific meaning of the terms steatite and soapstone, I include in them all those soft unctuous rocks, useful for economical purposes, which are composed almost entirely of talc. And my object is not to give any farther account of those extensive and numerous deposites of this substance in

Massachusetts which are described in my former report, but merely to notice a few new localities.

No. 214 is a specimen of laminated green talc from Fitchburg. I am told that the bed is four feet thick, and most of it of a much finer grain than this specimen. A smaller specimen sent me is nearly compact. If enough of either kind can be obtained, free from foreign minerals, there is no doubt but it may prove valuable.

Dr. Anthony Jones, of Newburyport, informs me, that he has discovered and owns a bed of soapstone on the banks of the Merrimack, two miles west of that place. But as I have seen neither a specimen nor the locality, I can say nothing more respecting it.

The most interesting and important locality of this rock, not formerly described, is in the east part of Andover, four miles from the Theological Seminary. The bed lies in hornblendic gneiss, whose stratification is very irregular and indistinct; but I ascertained its direction to be almost N. E. and S. W. and its dip large, corresponding in both respects with the great deposite of gneiss extending diagonally across the state. The bed is not less than 50 feet thick; and has been opened by the proprietors, Flint, Jenkins & Co., several rods in length. They have wrought it for a variety of purposes, and it admits of being smoothed so as to appear well. Its composition is remarkably uniform, consisting essentially of rather hard foliated talc, though occasionally a black mineral is disseminated through it, which appears to be hornblende. Its strength appears to be greater than marble; as the proprietors informed me that a square piece 2 inches thick, laid on two supports 18 inches apart, sustained 800 pounds, laid upon a spot in the centre only half an inch wide; 860 pounds broke it.

The specimen No. 213 gives no idea of this rock, except as it is newly broken from the quarry. The proprietors, however, inform me, that one or two monuments made from it, have been placed at Mount Auburn. And for such a purpose it seems well adapted. I cannot but believe that this rock, which is certainly a peculiar one, and quite different from ordinary soapstones, will ere long come into extensive use, and the enterprizing proprietors be rewarded for their expense and perseverance. It seems applicable to nearly every use for which marble is employed.

Large boulders of this rock are scattered over a considerable space around the quarry, in an east and west direction, and since the diluvial current in this region was from the north, these boulders render it probable that the bed is far more extensive than the spot which is opened; or that other beds occur beneath the surface.

22. SERPENTINE OR VERD ANTIQUE MARBLE.

A remarkably interesting bed of serpentine has been recently discovered in the town of Lynnfield, near the centre of the place, where a quarry has been opened. The proprietor, Mr. James C. Nichols, informs me that he has traced the bed in a north-east direction from this spot two or three miles. Where it crosses the county road leading from North Reading to Salem, about a mile and a half from the quarry, a large quantity was blasted out, which was too hard to be wrought without great difficulty. The bed has not been traced far to the south-east of the quarry, as the rocks are mostly concealed by diluvium. But the great quantity of serpentine blocks scattered in a rather south-west direction for two or three miles, show that it does extend that way a considerable distance: while their great number gives us a striking idea of the extent of the whole bed. There can be no such thing as exhausting it. Its width in some places is not less than nine or ten rods.

Although on the Geological Map of the State I have represented sienite as existing at the centre of Lynnfield, yet from the direction of the bed of serpentine, as well as the character of the diluvium, I am satisfied that it is embraced in the great gneiss formation whose strata run from north-east to south-west across the state. Probably the bed is not far from the eastern limits of this formation.

This serpentine, for the most part, appears to form that variety which goes by the name of Verd Antique Marble. When first quarried, "it is much softer," says the proprietor, "than any marble I have seen. It can be cut with a handsaw, or turned in a lathe, nearly as easy as *lignum vitae;* but while in this soft state it will not receive so high a polish." The specimen No. 215, which was polished and presented to the state collection by Mr. Nichols, will give an idea of common specimens of this stone. He says that "this serpentine can doubtless be wrought with less expense than common marble. We have made but a small opening, yet we have obtained some sound slabs five feet in length; and we shall doubtless find the stone sufficiently sound to afford slabs large enough for any ordinary purpose. We have not manufactured much of the stone, nor offered any for sale: yet we have full confidence that it would find a ready market."

Should it prove that this serpentine can be afforded at a cheaper rate than marble, I cannot see why it must not come into extensive use in all cases where a stone of a dark shade is preferred; though there will doubtless be found on exploration, pieces of various shades. The situation of the quarry so near the sea board, and in proximity with several of the largest towns of New England, is an additional reason why I look upon the discovery as one of much promise.

Dr. C. T. Jackson has analysed this serpentine with the following results:

Silica,	37
Magnesia,	42
Oxide of Iron,	2
Water,	15
Loss,	4
	100

Dr. Jackson suggests, that Epsom salts (sulphate of magnesia) and carbonate of magnesia, may be manufactured from this rock: and he says that from 100 grains of the rock he prepared 127 grains of dry sulphate of magnesia, which, when crystalized, will form 178 grains of Epsom salts. This will give, by decomposition with the carbonate of potassa or soda, 98 grains of the common carbonate of magnesia of the shops. A similar suggestion might be made in respect to the many other beds of serpentine in the state.

I here close my Report: not because I have exhausted the materials in my hands; but because some other points, which I would gladly have presented, have been examined by me too little to enable me to offer any remarks upon them that will be of importance. I have been surprised at the number of new objects of interest and value that have continued to offer themselves to my attention, up to the very day on which I close this Report. If I have presented results enough to satisfy the Government that a re-examination of our geology was not a useless labor, and that still farther developements may be expected, of pecuniary importance, as the fruit of still farther researches, I shall be satisfied. And should they wish me to prosecute my inquiries to a more mature result, I shall rejoice, if a kind Providence permit, to resume the labor; in the confident belief, that whoever contributes, even in the feeblest measure, to the prosperity of our beloved Commonwealth, is indirectly promoting the welfare of the whole human family.

Most respectfully submitted,

EDWARD HITCHCOCK.

Amherst College, April 1st, 1838.

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